POWER

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Reprehensible

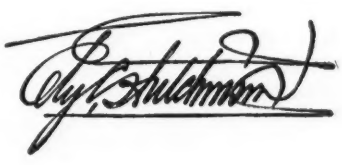
Being in the market for some power equipment, the purchasing company drew up specifications to cover its requirements. After the machinery was installed it turned out that some of the instruments did not do what was wanted. That is to say, the instruments filled the specification, but the purchaser had failed to state what he expected of them.

A subordinate, knowing this, wrote a requisition to headquarters for some proper instruments. But the executive in charge of purchases turned it down.

And that was not all. The subordinate was forcefully told to advise the vendor that the instruments were "unsatisfactory" and for that reason must be replaced by another type, without extra charge.

Thus the vendor was faced with the alternatives of insisting on his contract rights and jeopardizing his important friendly relationship or submitting to the squeeze and paying for the purchaser's oversight out of his own pocket.

It is probable that the purchaser would be terribly shocked were he told that what he had thought to be business acumen was in fact one small example of a rather common but morally reprehensible practice.



EDITORIALS

Buying Is an Operating Responsibility

Where the engineer must delegate the selection of power equipment he loses some control over power costs and quality of service. With it automatically goes part of his responsibility for these results, whether or not the management recognizes the fact.

If boilers or generating units or valves, or any other items of power equipment, are selected without the approval of the power engineer, or if his choice is hedged in by arbitrary restrictions, he cannot be held accountable for bad service, excessive maintenance or high fuel charges. How can one deny his alibi that the equipment is not suitable.

The honest and efficient engineer has no more fondness than the management for alibis, yet he dare not quietly accept the blame for conditions beyond his control. He desires nothing more than a set-up wherein he can stand or fall on his own performance. That means complete control centered in his hands alone.

Many industrial power engineers have fought for this status and have won the battle, to the benefit of all concerned. More specifically, some have made it a condition of employment as chiefs in plants not yet erected, realizing that a good start is half the battle. They have seen to it that the plant to be operated should contain no piece of equipment not personally acceptable.

Congratulations to such men and the profession they honor!

Better Diesel Exhaust Lines

The advances engineers have made in the design and construction of diesel engines have been tremendous. But the same adjective cannot be applied to installation practices, which have been somewhat ignored by the overburdened designers.

Exhaust pipes are considered entirely as a duct to pass the burned gases from the engine to the outside atmosphere. At times the piping may be extraordinarily long and tortuous, to avoid some local obstacle. The fact that the engine's back pressure may be raised a pound or so seems to be given little, if any, consideration. Such back pressures are especially objectionable in two-stroke-cycle engines of both the blower and crankcase-compression type, for an extra pound of pressure due to waste gases decreases the charging of the engine with fresh air. In four-stroke-cycle engines the extra pound decreases the engine's mean effective pressure and represents a loss of around one per cent in the engine's output and a corresponding increase in net fuel consumption.

If more attention were given to gas flow it would be possible to design the exhaust line of a length such that not only would excess back pressure be removed but a sub-atmospheric pressure obtained. This favorable condition could be obtained without any sacrifice in muffling the noise, for a properly designed silencer can be applied to a correct exhaust line so that the combined effect will be all that is desired.

Boiler-Water Treatment

One who has followed the trend of boiler-water treatment cannot fail to be impressed by the changes that have taken place in the last few years. Exact science is replacing rule-of-thumb methods and guess work to the great benefit of all who operate boilers.

Not many years ago, when a power house was to be built, a sample of water from the contemplated source of supply was sent to a chemist for analysis. When the chemical constituents were ascertained, the plant designer himself, or one of the companies providing water-treating apparatus, devised a method of chemical or other treatment and this was later installed. It was generally assumed that the method could be continued without variation as long as the plant operated. Few or no changes were made for seasonal differences in the character of the water supply. It is surprising how well these old boilers functioned under such treatment and how relatively few failures occurred. But at that time present rates of evaporation had not come into vogue. It is true that cleaning was a periodic routine procedure and tube replacements were frequent.

Now boiler-water treatment has become a scientific chemical procedure. Many of the present reagents were used in former days, not so intelligently perhaps, but still to good effect for those times. Soda, lime, phosphate, and open heaters to remove gases, were then in use, but their limits of utility were not known and their application was not controlled. Now we must maintain certain sulphate-alkalinity ratios; Ph values must not fall below a definite figure or corrosion is accelerated; oxygen must be kept below prescribed amounts; and the deaëration must be complete whether the feed water becomes cold or the deaërating steam supply is limited. Also the water in the boiler must be periodically analyzed.

This makes boiler operation a scientific procedure in which a fair knowledge by the operator of certain chemical reactions is necessary. When boiler men are not familiar with Ph, alkalinity and deaëration they labor under a severe handicap which should be overcome by quickly learning about these factors.

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POWER Stands for . .

1. Making Power When It Should Be Made
2. Buying Power When It Should Be Bought
3. Cheaper Power Through Modern Equipment
4. Easier Financing of Equipment Purchases
5. Better Use of Byproduct Heat and Power
6. Operating Methods That Save Money
7. Less Waste in Transmission and Application
8. Prevention of Smoke, Within Reason

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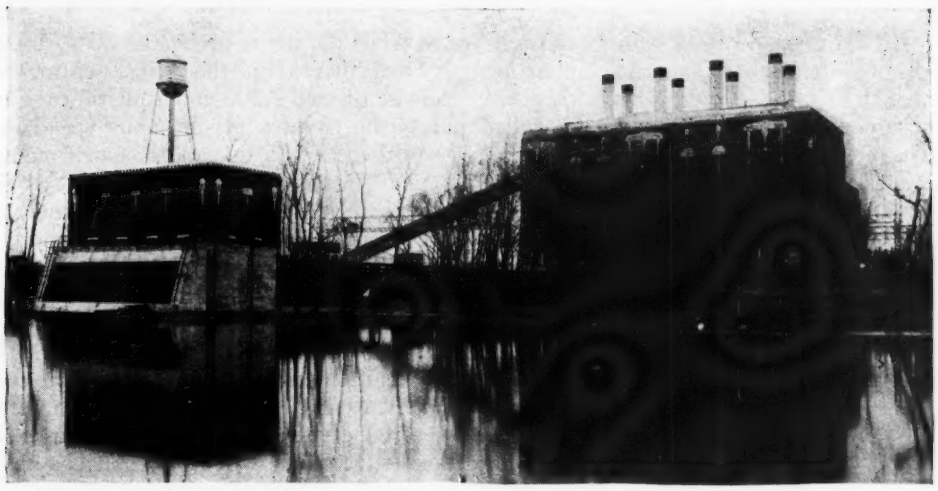


Harding Street Station at Indianapolis

Harding Street Station Gives Indianapolis Efficient Power Supply

High commercial economy secured through adoption of moderate steam pressure, 400 lb. and 700 deg. at turbine throttle. Underfeed stokers, economizers, air preheaters, stage bleeding and evaporators are used. Combustion is automatically controlled. Ashes are sluiced. With exception of stoker drive, use of squirrel-cage motors arranged for across-the-line starting at 2,300 and 440 volts

HARDING STREET generating station of the Indianapolis Power & Light Company, which was formally opened last November, is the latest and most modern of the subsidiary properties of the Utilities Power & Light Corporation. Housed in a building that the architect has made unusually attractive, the initial installation aggregates 70,000 kw. in two units. This is one-half of the capacity ultimately intended. Eventually it is the plan to extend the building and duplicate the present installation, bringing the total capacity to 140,000 kw. in four units, which is the approximate limit of the available water supply at the site on the White River, five miles southwest of Indianapolis.

Previously two stations, Mill Street with 50,000 kw. capacity and Kentucky Avenue with 30,000 kw. in generating equipment, supplemented by high-line service, met the electrical demands of the city. Equipment in these stations was becoming obsolete and additional capacity was needed to meet the growing requirements. Lack of room for expansion at the old locations near the center of the city and an inadequate supply of condensing water for the greater output made an entirely new plant and a change in site desirable.

The new plant feeds into a 132,000-volt loop surrounding the city, which is also tied in with the Public Service Company of Indiana's Dresser station at Terre Haute. In the case of the new plant this was particularly desirable, as the present load, running up to 80,000 kw., approximates the generating capacity. During the heating season the older plants will be operated to supply the steam needed for district heating and as much electrical energy as this steam will make available.

Design features of the new plant and the equipment in general are similar to those of the Raritan River station[1] at Sayreville, N. J., erected over a year ago for the same holding company by the Management & Engineering Corporation. Steam at 400 lb. pressure and a temperature of 700 deg. F. at the throttle figured to give the highest commercial economy. Intensive use of equipment that will insure the utmost return on the investment is to be secured by boiler operation up to 525 per cent rating. This is equivalent to a maximum output of 190,000 lb. of steam per hour from a unit containing 11,810 sq.ft. of surface.

There are eight boilers of the foregoing capacity, four per turbine, of the cross-drum type, built for a working pressure of 450 lb. and a steam temperature of 725 deg. F. at the outlet of an interdeck convection superheater. Both economizers and air preheaters have been installed, the former having about one-half as much surface as the boiler and the preheater of regenerative type 50 per cent more surface, or 17,800 sq.ft. Combustion air is preheated to 300 degrees.

Three of the four bleed points on the main turbines

[1]For description see *Power*, Jan. 20, 1931.

are in use to heat the feed water. Make-up is pretreated chemically ahead of the evaporators, which may be operated double- or single-effect. Automatic combustion control has been installed. A continuous blowdown system prevents high concentration of salts in the boiler water, and the exchanger, an integral part of the system, transfers the heat in the blowdown to the incoming feed water. Mechanically operated quick-acting safety valves on the steam manifolds, by their accurate functioning and quick closing, prevent waste of steam through the regulation safety valves on the boilers. A feature is the general use for auxiliary power of the simple and inexpensive constant-speed squirrel-cage motor arranged for across-the-line starting. An exception is variable-speed motors for the stokers. For the fans there are dual drives, consisting of high- and low-speed squirrel-cage motors. With this arrangement complication of motor and control equipment is obviated and reserve capacity is provided in the dual drive, for with the high-speed motor down, the other will carry approximately 60 per cent of the load.

Low price at the mine and low freight rates owing to the short haul made local coal the most economical fuel. To burn it at intensive rate, ten-retort underfeed stokers with link-grate overfeed sections and double-roll clinker grinders were selected. The projected area of each stoker, 348.6 sq.ft., bears a ratio to the boiler heating surface of 1 to 34.

The coal analyzes 11 to 15 per cent ash, 10 per cent moisture and 3.75 per cent sulphur. Water is maintained under the grates to minimize the clinkering characteristic of this coal.

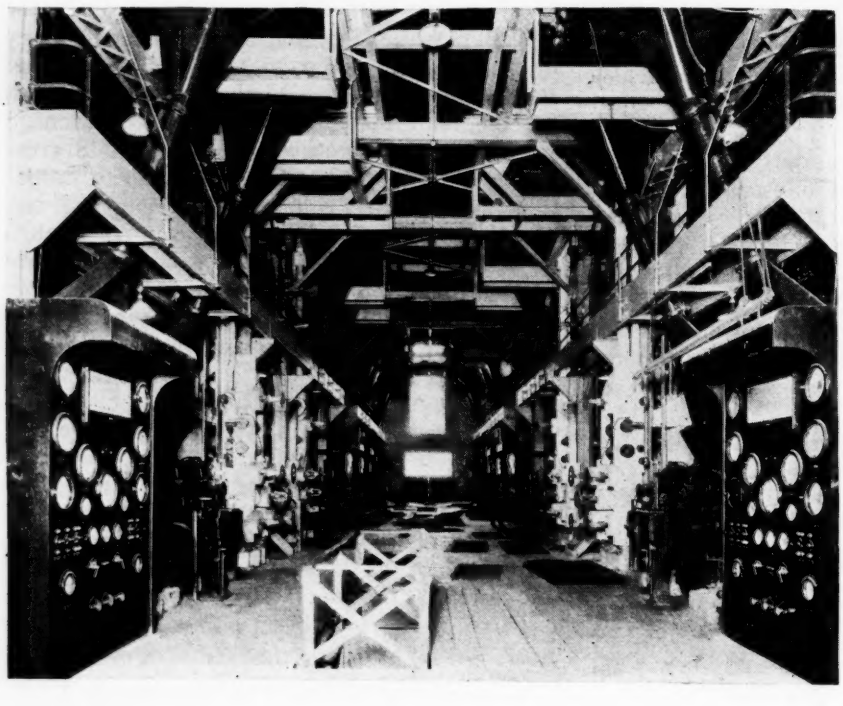
As indicated in the sectional elevation of the plant, the boilers are set high to provide a furnace volume of 6,500 cu.ft. The rear wall and the side walls for a height of 9 ft. above the grates and parallel with the fuel bed are water-cooled. Above the water-cooled section the side walls are air-cooled up to the boiler tubes. Air from the room is admitted through dampered inlets into vertical ducts and is collected by a metal duct at the top of the setting which leads to the individual forced-draft fan of the boiler. In its passage through the walls the air is preheated 80 to 150 degrees.

Dual drives on the 66,600-c.f.m. forced-draft fans consist of two 2,300-volt squirrel-cage motors, one rated at 60 hp. with a synchronous speed of 900 r.p.m. and the other at 125 hp. and a synchronous speed of 1,200 r.p.m. Rated at 110,720 c.f.m., each induced-draft fan is driven by 100- and 250-hp. motors, with synchronous speeds of 600 and 900 r.p.m., respectively. Operating at the normal load, calling for the generation of 124,000 lb. of steam per hour, the smaller motors are in service. At the higher ratings the higher-speed motors are needed. In four of the boiler units the changeover is made automatically by a combustion control system that correlates fuel, air and draft to the steam demand. A metered electrical combustion control on the other four boilers requires that the changeover from one motor to the other be made by push button.

Much of the air for supporting combustion passes through the fuel bed. The balance is supplied over the fire through nozzles in the front and rear walls. The temperature of the delivered air approximates 300 deg. F. Part of the heat is added as the air is drawn through the boiler walls by the forced-draft fans to be mixed with the general supply from the top of the boiler house and forced on through the preheater to the stoker windbox.

Water for boiler make-up and general use in the plant is drawn from two deepwells on the property and stored in a 50,000-gal. elevated tank. The water contains some hardness and acid, as the wells are 200 ft. from a river carrying the discharge from a sewage-disposal plant located one-half mile upstream.

From the overhead storage the water is admitted under float control to the make-up tanks. Another source of make-up supply is the low-pressure drains collected in the tank indicated in the water-flow diagram and pumped to the make-up tanks. Tracing the path of the water from the make-up tank, the supply first passes through the heat exchanger of the continuous-blowdown system on its way to the evaporator, which has a capacity

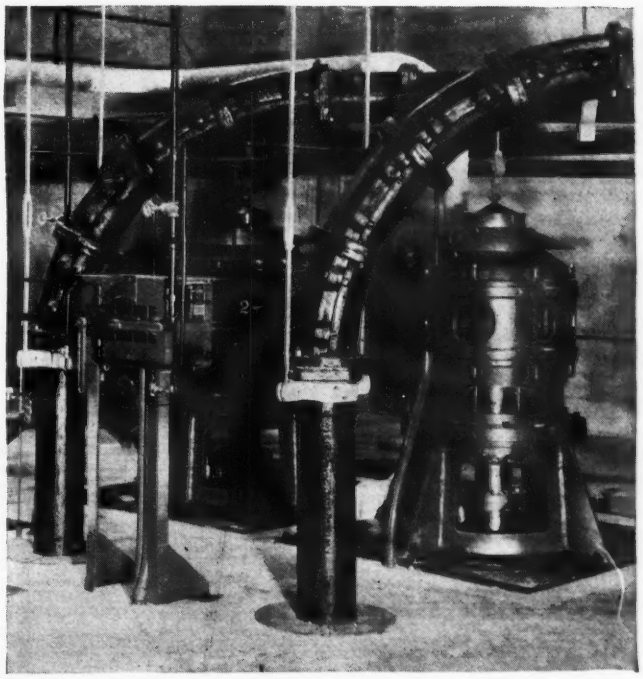


Central firing aisle for eight boilers of the cross-drum type operating at 450 lb. and 725 deg. and served by underfeed stokers

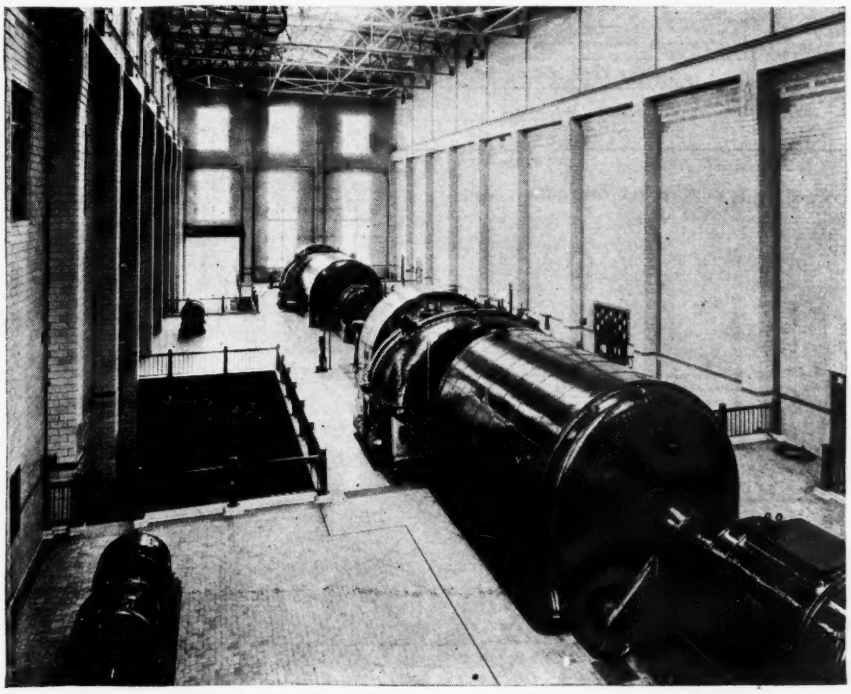
of 12,000 lb. per hour and may be operated double- or single-effect. Steam is supplied from the eighth-stage bleed line at a pressure under full load of 70 pounds absolute.

Condensed vapor from the evaporator passes to a surge tank, and its entrance into the feed-water system is regulated by a valve in the outlet under the control of a float in the open heater. From the surge tank the evaporated make-up passes to closed heater *A* to be mixed with extraction steam from the nineteenth-stage bleeder at 5.2 lb. abs. Drainage from the heater is pumped into the main condensate line. It will be seen from the diagram that the condensate from the main condenser first passes through the tubes of heater *A* and then through the tubes of the evaporator condenser to be spilled into an open heater of the direct-contact type which receives steam at 18.7 lb. abs. from the fifteenth-stage bleeder or from steam-using auxiliaries.

At full load feed-water temperatures into and out of the open heater are 172 and 217 deg. F., respectively. Three feed pumps of 400 g.p.m. each draw in common from this heater. Two of them are driven by constant-speed induction motors and one by turbine. They force



Motors driving vertical ash pumps with selective control mounted on pedestal in foreground

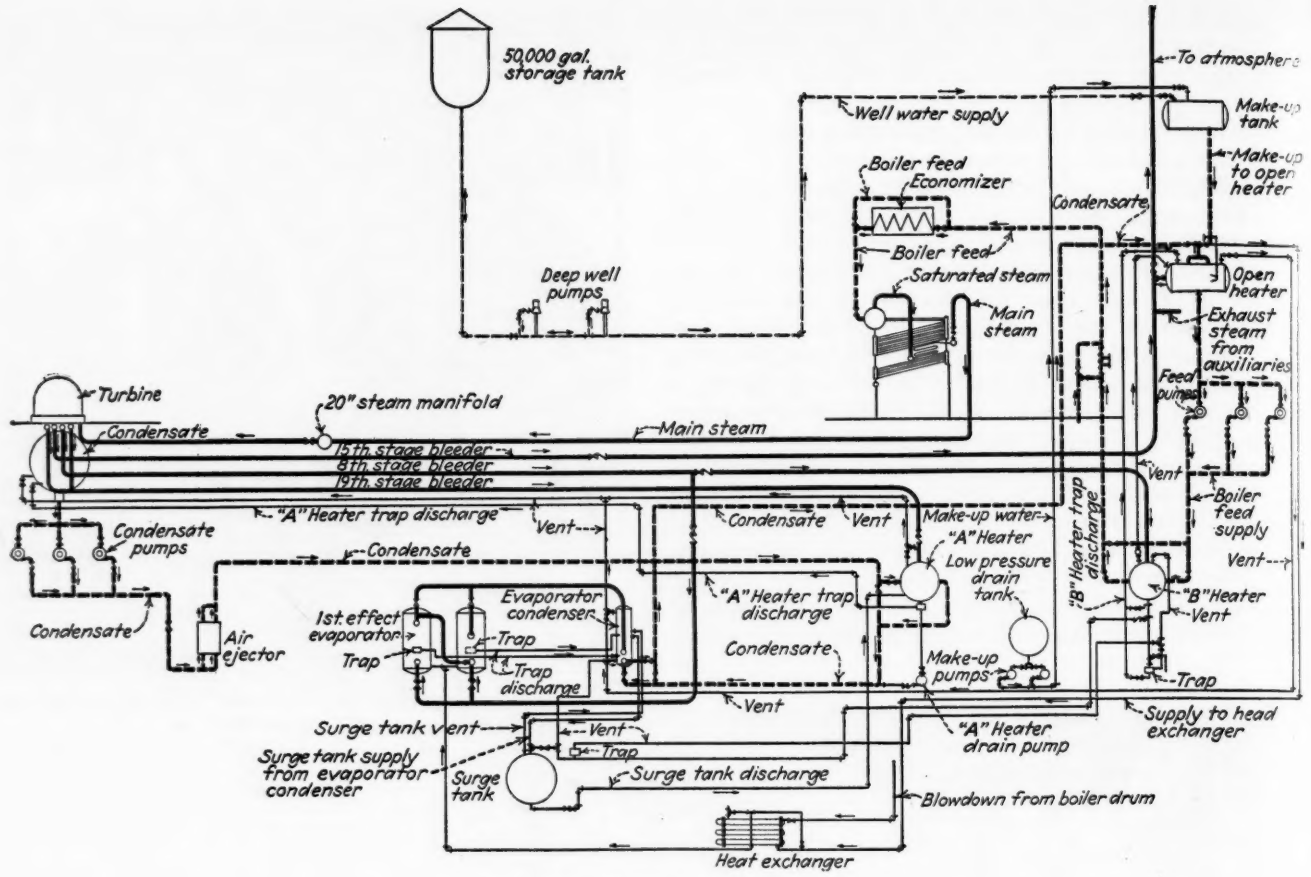


The present turbine room contains two 35,000-kw. units with direct-connected 1,750-kw. house generators

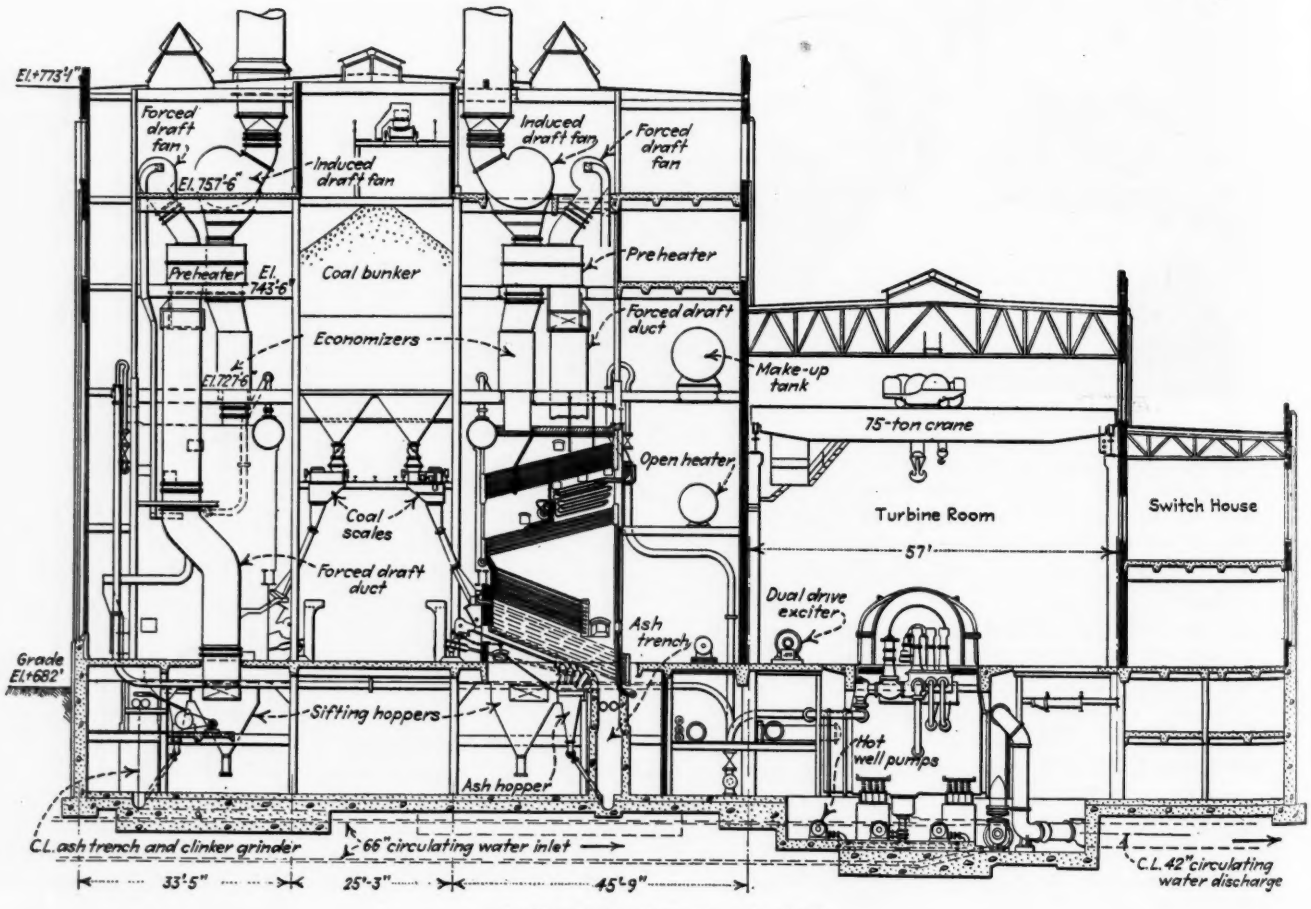
the feed through closed heater *B*, which, in common with the evaporator, draws steam from the eighth-stage bleed line, and on through the economizer to enter the boiler at both ends of the drum at a temperature approximating 380 deg. Water-level and differential-pressure regulators control the flow.

Coal is received by rail and dumped into a track hopper for delivery to the plant or into a pocket to be distributed by a gantry crane into under-water storage. For this purpose a concrete basin has been provided. When the coal is piled to a height of 31 ft. the storage capacity of this basin is 62,000 tons, with space to extend the basin length to 1,000 ft. and thus double the storage. To reclaim the coal the gantry crane places it on a longitudinal belt conveyor and transfer is made to a 36-in. belt conveyor leading from the track hopper to the crusher house. At the head of this conveyor is a magnetic pulley to separate the tramp iron from the coal before it passes to a 250-ton ring crusher, or bypasses the crusher to an inclined belt conveyor leading to the top of the boiler house and passing over the 2,600-ton concrete-lined steel bunker topping the central firing aisle. There is a weightometer in the conveyor run, and in the crusher house an automatic coal sampler. Every minute this device takes a sample of coal, mixes and crushes it, and delivers 2 per cent of its output into a sampling can for testing. The balance of the crushed coal is passed back to the conveyor. Two automatic coal scales per boiler weigh the fuel and non-segregating distributors deliver a uniform supply to the stoker hopper.

Ashes are sluiced from the hoppers under the boilers to a central sump from which they are pumped to the low ground on the site. Water for sluicing is drawn from the condenser cooling supply by the circulating pumps. The motors of these pumps are electrically interlocked with the motor of the clinker grinder, so that the starting of either pump automatically starts the clinker grinder. Of the two sump pumps, one is always maintained under float control to handle waste quenching water. When the hoppers are to be sluiced the second pump is started manually. If the water continues to rise the pump under float control will automatically start



Water flow diagram for boiler feed



Sectional elevation through plant

and continue to operate until the float shuts it down. That the installation is highly effective is indicated by the fact that an individual hopper holding 17 tons of ash has been emptied in twenty minutes.

Each of the main turbine-generators is rated at 35,000 kw. at 80 per cent power factor and 1,800 r.p.m. Steam conditions at the throttle of the turbines are 400 lb. and 700 deg. F. At full load each turbine takes 380,000 lb. of steam per hour, of which 65,000 is extracted from three stages. There are four bleeder points, one being blocked off, and four bleeder lines, but two of these lines draw from the same stage.

The generator is a three-phase, 60-cycle, 13,800-volt machine, with a 1,750-kw., 2,400-volt house generator on the same shaft served by a 20-kw., 125-volt direct-connected exciter. Excitation for the main generators is provided by three 175-kw. exciter sets, two being driven by motor and the third by a dual drive consisting of motor and turbine.

Each unit is served by a two-pass condenser, with divided waterbox, containing 33,000 sq.ft. of surface, or 0.94 sq.ft. per kilowatt. An automatic vacuum trip has been substituted for the usual atmospheric relief. It is set to close the throttle valve when the vacuum gets down to 15 in. Condenser cooling water is supplied by two propeller-type pumps rated at 17,500 g.p.m. Three condensate pumps care for full load on a unit. Two-stage ejectors remove the air, twin units being provided on one inter- and after-condenser.

Circulating water is drawn from the river through an intake house containing four motor-driven pumps and as many revolving screens, the allotment being two per unit. A 66-in. precast concrete conduit leads to the plant, and the return to the river is through a 72-in. conduit. In the 24-in. discharge lines from the pumps are motor-operated gate valves that are electrically interlocked with the pump motors. If it is desired to start or shut down a pump the respective valve is opened or closed through push-button control on the turbine room gage board. For the convenience of the operator similar controls for the circulating, condensate, and heater drain pumps are located on this board.

Electric generation is three-phase; 60-cycle, 13,800-volt. Transformers in an outdoor switch yard connected directly to the generators step up the tension to 132,000 volts. Each generator has air cooling and CO_2 fire protection. Excitation is provided by a 175-kw., 250-volt motor-driven set for each main generator set, with a spare exciter with dual motor and turbine drive available for either machine. Power for the auxiliaries is supplied normally by the 1,750-kw., 2,300-volt direct-connected house generators. As an alternate, auxiliary power is available from a bank of auxiliary transformers operating from the 132,000-volt bus. Motors of 50-hp. or larger operate at 2,300 volts and the smaller motors at 440 volts. Starting is at full voltage, with the bus switch functioning as the starting switch for the motor, and push-button control provided at convenient points. General station service switching is in the main switch house off the turbine room,

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Large Turbines in Great Britain

THE TREMENDOUS industrial development of the United States has made it possible for this country to lead the world in the size of steam turbine-generators as well as steam boilers and certain other pieces of equipment. This well-known fact has blinded many American engineers to the extent to which turbine units of large size have been built and installed in other countries, particularly in Great Britain.

The importance of British achievements in the steam turbine field are evident from the following condensed excerpts from the Jan. 1 number of *The Engineer* (London) which reviewed British engineering progress for 1931.

Work in hand at the Heaton works of C. A. Parsons & Company, Ltd., include three 50,000-kw, 1,500 r.p.m. turbine-generators for the Dunston station of Newcastle-on-Tyne Electric Supply Company, Ltd. As they are designed for interstage resuperheating of the steam, which is supplied to the high-pressure end at 600 lb. per square inch and at a total temperature of 800 deg. F., the turbines are of special interest.

A 15,000-kw, single-cylinder turbine-generator set—the largest in the world running at a speed of 3,600 r.p.m. —completed a continuous run of over twelve months in May of 1931.

Among the most important turbine-generators built by the Metropolitan-Vickers Electrical Company were two 71,500 kva., 1,500-r.p.m. sets for the Liverpool Clarence Dock power station.

Two sets corresponding to the 40,000-kva. turbine-alternator that has been in operation in the Victoria Falls Power Company's station for some time are in course of manufacture for the same undertaking.

The first of the 80,000-kva., 1,500-r.p.m. sets for the Battersea power station of the London Power Company is now practically complete; the second set is the largest 1,500-r.p.m. machines so far built in this country.

The British Thomson-Houston 10,000-kw., 3,600-r.p.m. turbine-alternator, designed for 365 lb. pressure, 1,000 deg. F. and 29 in. vacuum, and supplied to the Delray power station of the Detroit Edison Company, has been operating for some months under increasing temperature, and during November the final temperature of 1,000 deg. F. was reached.

The B.T.H. 67,200-kw turbine-alternator for the Battersea power station of the London Power Company is in course of erection on site. It is a three-cylinder machine, designed to operate at 570 lb. per square inch and 850 deg. F. and 29.1 in. vacuum.

The two 75,000-kw, three-cylinder turbine-alternators the firm is constructing for the new Barking extension of the County of London Electric Supply Company are claimed to be the largest machines ordered in England. Normally, they will operate with steam at 600 lb. pressure and a total temperature of 800 deg. F.

The 30,000-kw, three-cylinder machine for the Ford Motor Company's works at Dagenham will shortly be completed. It will be remembered that the turbine is designed for a pressure of 1,200 lb. and for a total temperature of 725 degrees.

A new 3,000-r.p.m., 45,000-kva, 11,000-volt, B.T.H. turbine-alternator put into service at the Stourport power station of the Shropshire, Worcestershire & Staffordshire Electric Power Company is said to be the highest-rated machine running in Britain at that speed.

Solubility of Water In Mineral Oils

By ALAN E. FLOWERS and MELVIN A. DIETRICH*

IN THE mechanical purification of oils fairly high temperatures are frequently employed, or advocated, to accelerate the rate at which such purification can be performed. Little or no attention is paid to the fact that at these temperatures it is possible for mineral oils to dissolve a considerable quantity of water, particularly if during such purification the oils are in intimate contact with water or aqueous solutions. Water dissolved in an oil at a high temperature will precipitate when the oil is cooled and cause a cloudy appearance which is sometimes erroneously ascribed to the precipitation of wax. Such precipitated moisture may cause numerous difficulties, such as loss in insulating value for transformer oils, deposition of sludge and emulsion in turbines or assist in corrosion of parts in refrigerating units.

Water determinations on samples of oil taken in the field show that even at relatively low temperatures oils may contain appreciable quantities of dissolved water, the amount being dependent to a considerable degree upon the relative humidity of the air. Insulating oils purified at high temperatures may lose 50 per cent of their dielectric strength on cooling, because of precipitation of dissolved moisture. Dissolved moisture can be partly removed by filtration through thoroughly dried papers and by exposure to air at less than 100 per cent relative humidity.

Investigations covered in this article were made to determine the extent to which water is soluble in various grades of mineral oils and to discover what oil characteristics could be most closely correlated with water solubility.

The method used for determining the quantity of dissolved moisture was that described by Rodman. In brief, the method consists in shaking the oil in a flask at a temperature of 120 to 140 deg. C. (248 to 284 deg. F.) and at a pressure of 1 mm. of mercury (0.019 lb.) or less. Under these conditions the partial pressures of oil and water are far apart, and separation of the two components is readily accomplished. The water, along with some light ends of the oil, is collected in a trap surrounded by a carbon dioxide-acetone bath. After twenty minutes of heating and shaking of the oil sample this part of the apparatus is stopped, the carbon dioxide-acetone bath is removed from the trap and redistillation of the condensed water vapor in the trap takes place. This vapor is collected in a phosphorus-pentoxide tube and weighed. To secure a high degree of accuracy the apparatus must be thoroughly dried and evacuated before each determination, and blank determinations must be interspersed frequently between determinations on oil samples. The phosphorus-pentoxide tube must be recharged frequently to prevent absorption of oil vapors and eliminate a high pressure gradient through the tube. With these precautions an average accuracy of 10 p.p.m. can be obtained. Attempts were made to use dehydrite and anhydrone in place of phosphorus pentoxide, but the results were erratic.

The oils to be tested were saturated with water by vigorously stirring 300 c.c. of oil with 100 c.c. of distilled water for three hours in a beaker, maintaining the mixture at the temperature desired during this period. After agitation had been stopped the beaker was covered with a watch glass and the mixture allowed to settle for two or three minutes in a water bath which was maintained at the temperature of the test. The partly cleared oil was decanted into 100-c.c. centrifuge tubes, previously warmed, corked tightly, and spun at 1,500 r.p.m. on an 18-in. swing until clear. The temperature in the centrifuge was controlled by injecting steam into the jacket. Moisture tests were made on this centrifuged oil.

Six unused oils were investigated, including two insulating oils, a spindle oil, one medium and two heavy turbine lubricating oils. With the exception of a preliminary centrifuging, the oils were given no special purification (unless otherwise stated) prior to saturation with water, and thus represented the condition in which they would be supplied to switches and circuit breakers, transformers and turbines. The physical characteristics of the oils are given in Table I.

The solubility-temperature curves for oils No. 1, 2 and 3 are given in Fig. 1, those for oils No. 4, 5, and 6 are given in Fig. 2. For comparative purposes the data obtained by Groschuff on a paraffin oil with a specific gravity of 0.883 at 18 deg. C. (64 deg. F.), is also plotted in Fig. 1. Inspection of these curves shows that the solubility of water in oils increases quite rapidly with temperature and that the oils vary considerably in their ability to dissolve water. At temperatures of 95 deg. C. (203 deg. F.), or above, the solubility in some of these oils exceeds 620 p.p.m., or 0.062 per cent. In general, the increase in solubility is greatest above 50 deg. C. (122 deg. F.). Thus if oil No. 6, saturated with water at 80 deg. C. (176 deg. F.) is cooled to 50 deg. C. it may

TABLE I — PHYSICAL CHARACTERISTICS OF OILS

Oil No.	1	2	3	4	5	6
Description	Insulating	Insulating	Spindle	Turbine	Turbine	Turbine
Specific gravity at (60 deg. F./60 deg. F)	0.905	0.847	0.916	0.890	0.932	0.913
Flash point, deg. F.	310	295	295	410	355	350
Fire point, deg. F.	345	330	330	480	400	395
Pour point, deg. F.	Below —35	20	Below —35	25	0	Below —25
Saybolt universal viscosity at 100 deg. F, sec.	85	52	72	243	307	157
Steam emulsion number, sec.	45	13	105	229	251	63
Neutralization number, mg. KOH per gm. oil.	0.01	0.01	0.01	0.01	0.02	0.01

*The DeLaval Separator Company, Poughkeepsie, N. Y.

be expected to precipitate 110 p.p.m. of water, while in cooling from 50 deg. C. (122 deg. F.) to 20 deg. C. (68 deg. F.) it will precipitate 65 p.p.m. It is evident that in the purification and handling of oils in which the possibility of the presence of suspended moisture is detrimental, temperatures should be maintained as low as possible. These temperatures ought certainly not to exceed 50 deg. C. (122 deg. F.) and should preferably be below 30 deg. C. (86 deg. F.). This conclusion is especially applicable to the purification of switch and transformer oils.

No single oil characteristic appears to have a predominating effect on the quantity of water which each oil can dissolve. There is an approximate relationship between the amount of water dissolved at 100 deg. C. and the A.S.T.M. steam-emulsion number as shown in Fig. 3. The A.S.T.M. steam-emulsion number is generally regarded as a measure of the degree of refining to which the oil has been subjected and the thoroughness with which the refining agents and their products have been removed. That a refining process effecting a reduction in steam emulsion number will materially reduce the solubility of water, other factors being the same, is shown in the curves in Fig. 4. In this case oil No. 3 was treated with 2 per cent by weight of fullers earth fines (200 mesh up) at 120 deg. C. (248 deg. F.), the steam emulsion number being thereby reduced from 105 to 25 sec., and the solubility for water reduced approximately 50 per cent, so that it approached that of oil No. 2, which had a steam-emulsion number of 13 seconds.

Factors other than the degree of refining as measured by the A.S.T.M. steam-emulsion number may exert an effect on the quantity of water that an oil can dissolve. This is evident from examination of data obtained on a water-white lubricating oil (No. 7 oil) which had apparently been subjected to a drastic refining. The steam-emulsion number of this oil is comparable to that of oil

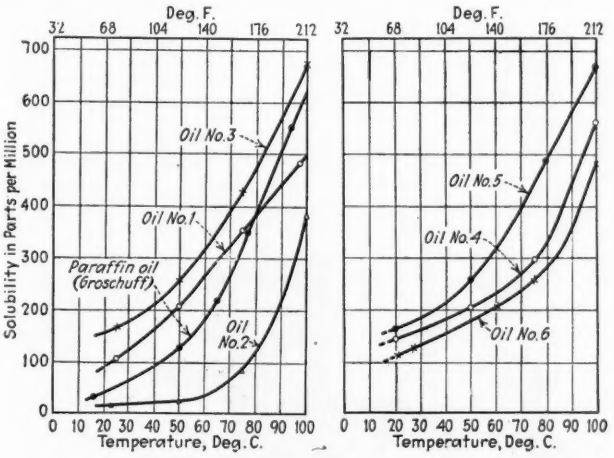

Fig. 1 and 2—Effect of temperature upon the solubility of water

No. 2. A limited number of data were obtained on this oil. The solubility of water in this oil is considerably higher than would be expected from its other characteristics and appearance.

Its specific gravity at 15.5 deg. C. (60 deg. F.) was 0.888, the viscosity at 37.8 deg. C. (100 deg. F.) was 312 sec. and the steam emulsion number 15 sec. At saturation temperature of 35 deg. C. (95 deg. F.) the dissolved water was 99 p.p.m., at 55 deg. C. (131 deg. F.) the parts per million was 141.

To determine how much dissolved water one may expect to find in an oil under actual operating conditions, several samples of oil No. 6, which had been taken in a refinery after the final processing step through a centrifugal separator, were analyzed. The results are given in Table II.

TABLE II — DISSOLVED WATER IN FIELD SAMPLES OF OIL NO. 6

Temperature, Deg. C.	Parts per Million of Dissolved Water	Saturation Value for Water Solubility at Temperature Given*	Per Cent Saturation Oil
19	91	110	83
21	93	112	83
38	120	150	80
49	97	175	55
49	112	175	64

* Estimated from solubility-temperature curve in Fig. 2.

Since this oil was not directly in contact with water during this stage of processing, the dissolved moisture present is presumably controlled by the humidity of the air. Gurwitsch makes the statement that petroleum lubricating oils are very hygroscopic, especially when heated. From the data in Table II it appears that oils are appreciably hygroscopic even when cool.

The extent to which mineral oils will absorb moisture from the air will evidently depend on the relative humidity of the air and the conditions of exposure. The effect of a change in relative humidity on the dissolved water content of oil No. 6 is shown by the following test results. Two portions of oil No. 6 were thoroughly dehydrated in the apparatus used for the moisture determinations and were then exposed to the air for four hours in evaporating dishes covered with watch glasses, which were raised slightly to permit free access of air. The relative humidity of the air was determined with a sling psychrometer. The data obtained are given in Table III and agree quite well with those given in Table II with respect to the amount of moisture found in oils exposed to moist air.

TABLE III — EFFECT OF RELATIVE HUMIDITY ON DISSOLVED WATER CONTENT

Relative Humidity of Air Per Cent	Area of Oil Exposed Sq. Cm.	Temperature of Test Deg. C.	Parts per Million of Water Dissolved by the Oil	Per Cent Saturation of Oil
58	63	26	70	56
75	63	27	110	86

These results show that an oil, even though completely dehydrated will, if exposed to air containing moisture during handling, quickly reabsorb moisture from the air and come to an equilibrium which will be dependent upon the temperature and the humidity. Occasionally, processes have been proposed for completely removing dissolved water from an oil, but it is questionable whether they are of any real value unless the dehydrated oil is subsequently completely protected from contact with the atmosphere.

The effect that too high a temperature of purification may have on the dielectric strength of insulating oils was determined for oils No. 1 and 3. In each case a batch of oil was dried overnight with calcium chloride and filtered in a dry atmosphere. One portion of each oil was saturated with water at 23 deg. C. (73 deg. F.) and another portion at 60 deg. C. (140 deg. F.). The latter portion was allowed to cool in a corked bottle at 23 deg. C. (73 deg. F.). The dielectric test, using A.S.T.M. Method D 117-31, made on each of the oils so treated gave results as recorded in Table IV.

TABLE IV — DIELECTRIC TEST VALUES

Oil No.	Dried Over Calcium Chloride and Filtered, Kv.	Saturated at 23 Deg. C., Kv.	Saturated at 60 Deg. C Cooled to 23 Deg. C., Kv.
1	37	40	19
3	38	39	20

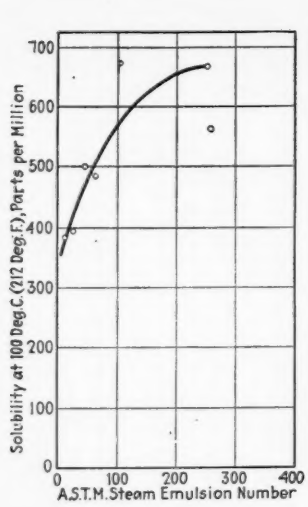

Fig. 3 — Relation between steam-emulsion number and solubility

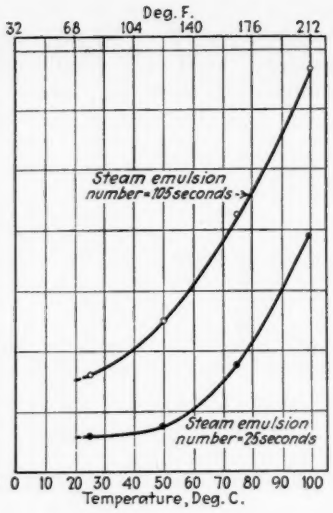
Deg. F.
32 68 104 140 176 212
Steam emulsion number=105 seconds
Steam emulsion number=25 seconds
0 10 20 30 40 50 60 70 80 90 100
Temperature, Deg. C.

Fig. 4—Effect of change in steam-emulsion number in oil No. 3

In these cases handling of the oils at a comparatively high temperature with subsequent cooling resulted in a loss of approximately 50 per cent in the dielectric strength because of moisture precipitated from solution. It should be borne in mind, however, that the presence of suspended moisture does not always reduce the dielectric strength of an oil.

Partial removal of dissolved water can be effected by passage through carefully dehydrated filter or blotter paper. This removal is not effected by a real filtering process but by absorption of water by the fibers up to some equilibrium value. The amount of water that can be removed by this method is determined chiefly by the increasing degree of saturation of the filter paper as "filtration" progresses. The amount of water that can be absorbed by filter papers is comparatively small and quickly drops with continued filtration, so that to attempt to compensate for high temperatures of handling oils by a final filtering operation to remove the dissolved moisture is impracticable. Filtration through dried blotter paper will remove some of the dissolved moisture, reducing it to some fraction of the saturation value, but the oil will immediately reabsorb moisture until in equilibrium with the atmospheric humidity. The best results are secured by handling the oils at moderate or low temperatures, using mechanical separation to remove precipitated moisture.

The thoroughness of the removal of dissolved water by dried filter papers was determined for oils No. 1 and 3; 100 c.c. of the saturated oil sample was filtered through one No. 2 Whatman 11.0-cm. paper weighing 0.9544 grams. The filtration was performed in a covered hot-water funnel maintained at the temperature at which the oil was saturated. The data given in Table V are specific for the conditions under which the experiment was performed, but do show that a high degree of removal of dissolved moisture can be secured by filtration if the filter papers are thoroughly dried before filtration.

TABLE V — REMOVAL OF DISSOLVED WATER BY FILTRATION

Oil No.	Temperature of Saturation Deg. C.	P.P.M. of Dissolved Water Before Filtration	P.P.M. of Dissolved Water After Filtration	Water Absorbed Cms. per Gm.	Per Cent Saturation of Filtered Oil
1	97	482	115	0.035	24
1	75	362	44	0.030	12
3	100	676	90	0.056	13

An effort was made to determine the capacity of used oils for dissolving water, but work was discontinued temporarily when it became evident that the present method for determining dissolved moisture was not suitable for used oils, since decomposition products from these oils collected in the phosphorus-pentoxide tube.

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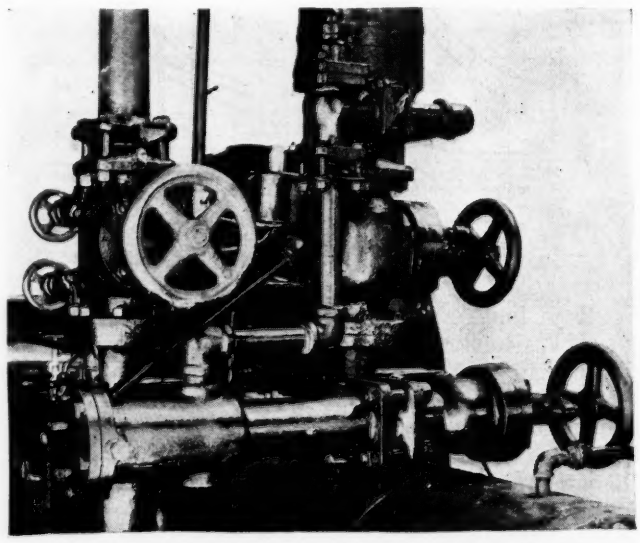
Application of Unloaders To Synchronous-Motor Compressors

By CARL C. NELSON*

SYNCHRONOUS MOTORS for reciprocating compressors, such as ammonia and air, ordinarily have low starting pull-in torques, inasmuch as the compressor is unloaded during the starting period. Formerly it was necessary to unload the compressor only when the operator started the motor for a regular run. This was readily accomplished by the operator, who manipulated various valves and switches to get the motor and compressor running.

However, with transmission lines becoming more extensive, and voltage conditions more subjected to line disturbances, synchronous motors were more likely to drop out of step. This trouble was caused by the reduction in torque due to decrease in voltage. Because of the low starting and pull-in torques the motor could not overcome the peak loads and come back into synchronism without being unloaded by the operator. Even with automatic starters the trouble was not overcome, because of the need of a suitable automatic unloader to operate with proper automatic resynchronizing apparatus.

Quick-acting automatic unloaders can now be applied to compressors, which, in combination with automatic starters of the resynchronizing type, give continuous



Quick-acting, electrically operated automatic unloader on ammonia compressor to obtain continuous operation through voltage dips

*Control Engineer, Electric Machinery Mfg. Co.

operation through voltage dips. This automatically eliminates the necessity of manipulating various valves and switches to resynchronize the motor. Voltage dips are very short, on the order of a fraction of a second. Therefore, any devices that operate to carry the motor through a voltage disturbance must operate instantaneously in order that the motor can be brought back into synchronism with the least delay. With the resynchronizing system it is only necessary to apply a suitable unloader, which will immediately function to unload the compressor as soon as the motor pulls out of step because of a drop in voltage. The sequence of operation follows:

As soon as the motor is desynchronized for any reason the frequency-type synchronizing relay operates to open the field switch, removing excitation. In turn, the automatic unloader operates instantaneously to unload the synchronous motor which continues running as an induction motor. Upon restoration of normal voltage the motor accelerates, resynchronizes, and the automatic unloader functions, allowing the motor to again take load.

Such operation gives maximum use of the apparatus, minimizes interruptions, and allows the operator to make use of his available time with no fear that he must rush to his machines during a voltage dip.

▼

Using a Watt-Hour Meter To Check Motor Loads

By M. M. McINTIRE*

IT IS QUITE general practice to make periodic checks on motor loads. For these tests voltmeters and ammeters or indicating or recording wattmeters are usually used. Where these meters are not available and a watt-hour is on the line it may be used to measure the load. To determine the power taken by an electrical load that is connected to a watt-hour meter all that is necessary is to time the revolutions of the meter's disk and apply the proper constants. A rapidly fluctuating load cannot be accurately measured in this way and should not be attempted. This method has been applied by the author to testing pump motors with satisfactory results and the disk constants given in the tables were assembled for use in the work.

A stop watch is preferred to time the disk, but fairly accurate results may be obtained with the second hand of an ordinary watch. The time for 10 or 20 revolutions of the disk should be taken and the values used in the formula for the watt load:

$$Watts = \frac{N \times 3{,}600 \times K}{T}$$

where N is the number of revolutions made by the meters's disk; T the time in seconds for N revolutions; and K the disk constant, which equals watt-hours per revolution. Values of K for various makes and types of watt-hour meters are listed in the tables. On most meters the test constant K is marked on the disk.

Assume a 50-amp., 440-volt Westinghouse 3-phase meter and that the meter's disk was timed and found to make 15 revolutions in 35 sec. In Table I the value of K is given at $26\frac{2}{3}$. Then the watts load $= \frac{15 \times 3{,}600 \times 80}{45 \times 3} = 32{,}000$ watts, or 32 kilowatts.

*Electrical Engineer, Imperial Irrigation District.

TABLE I — VALUES OF THE CONSTANT K FOR THREE-PHASE WATT-HOUR METERS*

Westinghouse, All Types; Sangamo Type HC; Duncan MD

Amperes	100 to 120 Volt Group	200 to 240 Volt Group	400 to 480 Volt Group
5	$\frac{3}{4}$	$1\frac{1}{2}$	$2\frac{1}{2}$
10	$1\frac{1}{3}$	$2\frac{2}{3}$	$5\frac{1}{3}$
15	2	4	8
25	$3\frac{1}{3}$	$6\frac{2}{3}$	$13\frac{1}{3}$
50	$6\frac{2}{3}$	$13\frac{1}{3}$	$26\frac{2}{3}$
75	10	20	40
100	$13\frac{1}{3}$	$26\frac{2}{3}$	$53\frac{1}{3}$

* Single-phase meters using half the above values are Westinghouse, all types; Duncan type MD; Sangamo type HC. Sangamo two-wire type D-5 use same constants as for three-phase.

TABLE II — DUNCAN TYPE, M-2 THREE-PHASE*

Amperes	100 to 120 Volt Group	200 to 240 Volt Group	400 to 480 Volt Group
5	0.5	1	2
10	1	2	4
15	1.5	3	6
25	2.5	5	10
50	5	10	20
75	7.5	15	30
100	10	20	40

* Duncan type M-2 single-phase uses values equal to one-half those for three-phase.

TABLE III — SANGAMO TYPE H THREE-PHASE*

Amperes	100 to 120 Volt Group	200 to 240 Volt Group	400 to 480 Volt Group
5	5/12	5/6	$1\frac{3}{4}$
10	5/6	$1\frac{3}{4}$	$3\frac{1}{2}$
15	$1\frac{1}{4}$	$2\frac{1}{2}$	5
25	2 1/12	4 1/6	$8\frac{1}{2}$
50	4 1/6	$8\frac{1}{2}$	$16\frac{3}{4}$
75	$6\frac{1}{4}$	$12\frac{1}{2}$	25
100	$8\frac{1}{2}$	$16\frac{3}{4}$	$33\frac{1}{3}$

* Sangamo type H single-phase uses values of one-half those for three-phase.

TABLE IV — GENERAL ELECTRIC TYPE D-14*

Amperes	100 to 120 Volt Group	200 to 240 Volt Group	400 to 480 Volt Group
5	1.2	2.4	4.8
10	2.4	4.8	9.6
15	3.6	7.2	14.4
25	6	12	24
50	12	24	48
75	18	36	72
100	24	48	96

* G. E. type I-16 uses values one-half those in this table.

TABLE V — GENERAL ELECTRIC TYPE D-7*

Amperes	100 to 120 Volt Group	200 to 240 Volt Group	400 to 480 Volt Group
5	0.6	1.2	2.4
10	1.2	2.4	4.8
15	1.8	3.6	7.2
25	3	6	12
50	6	12	24
75	9	18	36
100	12	24	48

* G. E. type I-14 uses values one-half those given in this table.

For all meters larger than 100 amp. the constant K may be computed by the formula $K = \frac{\textit{Ampere capacity of meter} \times \textit{constant for 5-amp. meter}}{5}$

In the event that the meter installation includes current transformers or potential transformers, or both, the constant K for the meter will have to be multiplied by the ratio of the transformer used.

Assume a motor load metered with a 100-amp., 440-volt General Electric Type D-14 meter and the time taken for 10 revolutions of the disk at time of test as 80 sec. Since, from the tables, the constant K for this meter is 96, the load at the time of test would be:

$$Watts = \frac{10 \times 3{,}600 \times 96}{80} = 43{,}200 \text{ watts,}$$

or 43.2 kilowatts.

If this installation had included a set of 20-to-1 current transformers, a 5-amp., 440-volt meter would have been used, which has, in this type, a constant of 4.8. Multiplying this by the transformer ratio the constant 96 is obtained, which is the same as would be used if the 100-amp. meter was installed. If a potential transformer had been used with a 4-to-1 ratio, a 110-volt meter would have been employed, but the constant would not have changed, as the 110-volt meter constant multiplied by the ratio 4 gives the same result as for the 440-volt meter.

Light-Weight Diesels For Air Service

By OLIVER F. ALLEN
Consulting Engineer
New York City

It seems a far cry for the heavy and bulky oil engine discussed in earlier articles of this series to the aircraft diesel. But industry needs lighter-weight, higher-speed and cheaper prime movers, and new alloys and design details that make possible the development of large-capacity aircraft diesels will be applied to improvement in power plant engines

IT MAY seem strange to some readers that a study devoted to power, which many are prone to think of only as turning the wheels of industry, should concern itself with air service engines. As the world constantly needs better, lighter-weight, more compact and lower-cost prime movers, power users and producers are seeking the easiest way to secure improvements. Lighter weight means less expense for transport from point of manufacture to place of use, combined with less expensive supporting structure. A more compact unit means less investment for space and for protecting structure. Improved performance and lower cost mean increased utilization and reduced power charges.

To accomplish these results the industry must take advantage of technical developments which are inherently expensive. Such developments include more data about combustion and combustion chambers, higher temperatures and higher brake mean effective pressures, better distribution of both mechanical and heat stresses and more efficient utilization of materials, both as to kind and distribution, so as to reduce both weight and manufacturing costs, while improving performance.

The history of gasoline-engine design, especially in England, France and Germany, points to the development of the aircraft oil engine as the quickest, simplest and cheapest way to secure these data.

As to the second question, engineers are inclined to overlook the power aspects of modern aircraft. Taking the automotive industry as a whole, one will find the highway vehicle limited to about 200 hp., with very few of the heaviest trucks or buses having power plants of over 150 hp. The largest railcars do not require over 1,000 hp., and the most powerful oil-engine locomotive is about 2,000 hp. Steam locomotive experience makes it doubtful if single units of over 6,000 hp. will ever be required. The aircraft industry is new, and high-powered planes and airships are a development of the last few years, yet there are planes in actual service with over 6,000 hp. each and others definitely projected requiring 10,000 hp. There are many planes in regular commercial service with power plants of the order of 1,000 to 1,500 hp. The airplane and the airship have already outstripped both the highway and the railroad conveyances in unit power plant requirements.

The diesel motor for air service, therefore, presents one of the most important outlets for prime movers of large capacity. While a group of relatively small engines is now employed, there is no reason to doubt that the larger units will be used as soon as they are obtainable. This is an outlet of special interest to manufacturers, because engines built for these services will fill an entirely new field and not replace any existing power supply.

The successful solution of the problems of large-capacity oil engine aircraft power plants will not only be a constructive new development in itself, but will give material aid to the improvement of the other types, for stationary, marine, rail and highway services.

For some twenty years the demand for aircraft motors has been an important factor in improving the gasoline engine. Reduction in weight per horsepower of the automobile gasoline engine from 30 lb. to 10 lb. has been a great accomplishment, but the reduction to 1 lb. for aircraft motors has been a greater achievement.

Fig. 1—Cross-section of the Junkers opposed-piston diesel, of 4 1/8-in. bore and 8 3/4-in. stroke

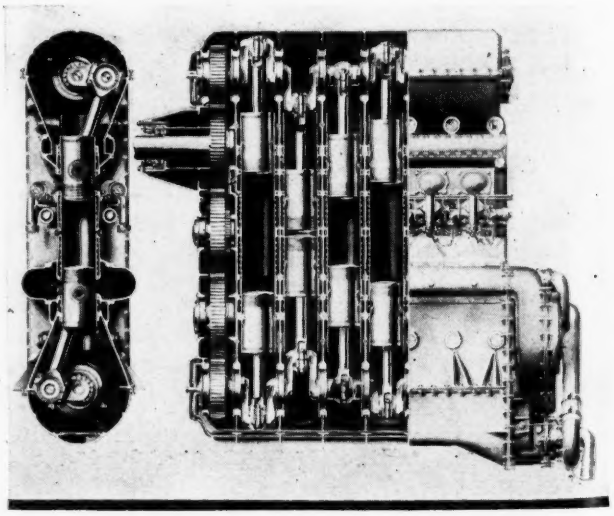


Fig. 2—A Ballanca plane fitted with a Packard diesel

Until five years ago little serious thought was given to the use of non-volatile, safe fuels for air service. Neither the diesel nor any other type of fuel-injection engine was even experimentally available. The demand developed as the cruising radius of planes increased and the importance of greater safety was realized. For short flights the relation between the weights of fuel, plane and useful load is not so important, but for flights of hundreds of miles, which are now standard practice, a substantial increase in fuel economy, even when it entails a heavier engine, results in reduction of total load to be lifted at starting, increases the pay load which may be carried and extends the cruising radius without refueling.

When the oil engine was first seriously studied for air service, the gasoline engine consumed on the order of a pound of fuel per brake-horsepower-hour. That has been reduced to about 0.66 lb. as a general rule and to below 0.5 lb. under the most favorable conditions. The diesel aircraft motor started at little over 0.5 lb. and is down to 0.33 lb. in the most efficient of the existing types. In spite of its youth, the aëronautical oil engine has kept ahead of the gasoline engine in fuel economy, and can be considered as generally requiring only between two-thirds and three-quarters of the fuel of the corresponding gasoline engine. This means a tremendous increase in cruising radius with a given supply of fuel, or in pay load for a given long-distance flight.

In the multi-cylinder, high-speed gasoline aircraft engine, even when a supercharger is used to help mix the fuel and air, it is difficult to get uniform distribution of load among the cylinders and uniform firing of the charges in the cylinders. Present developments indicate that with the injection type of motor, both the distribution of the load between the cylinders and the uniformity of firing can be improved, and that, as soon as there is more experience with diesels in actual service in the air, they will prove to be superior to gasoline engines in general performance, as well as in fuel economy.

The work of such organizations as the air services of the United States, England, Germany, Italy and France, and such commercial groups as Packard, Rolls-Royce in England, Fiat in Italy, and Junkers in Germany affords substantial proof of the practicability of the light-weight, high-speed oil engine, involving the employment of stresses and strains substantially in excess of those utilized in any other field in which the injection engine has been applied. Up to the present time these engines have not had any general commercial use. Their weight per horsepower is still two to three times that of the lighter gasoline engines, but it is already little enough to justify their use.

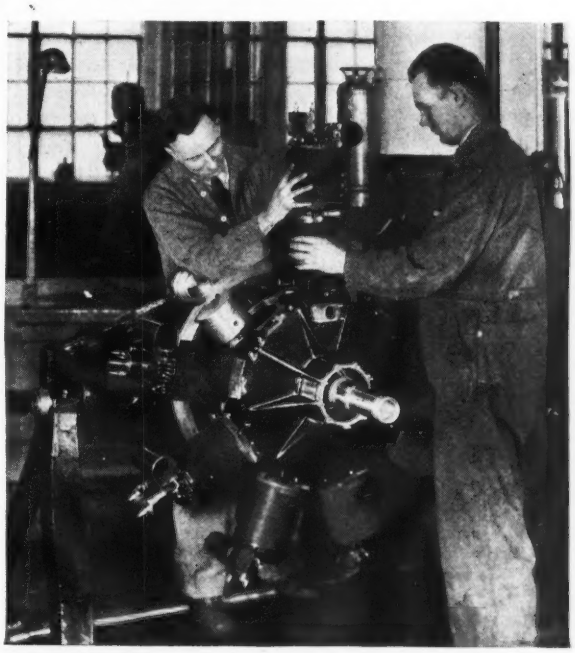


Fig. 4—Assembling a Packard two-stoke-cycle aircraft diesel

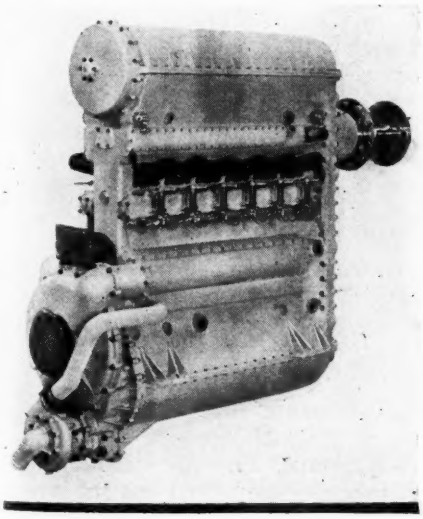


Fig. 3—The Junkers diesel viewed from the blower end, rated at 720 hp. at 1,715 r.p.m.

In this country, Germany, England and France, experimental engines have been built by several manufacturers and tried out by the military air forces. A few have been tried in commercial service. The results of these experimental flights have been very encouraging, and the development of the oil engine for air service is going ahead actively in several countries.

In Germany diesels were demonstrated in planes about three years ago, and have been continuously studied ever since. The outstanding accomplishment there is the Junkers 750-hp. two-stroke-cycle, opposed-piston engine shown in Figs. 1 and 3. After exhaustive trials these engines have been placed in regular commercial airplane freight service.

Miniature Boiler Operates at 1,100 Deg. and 1,600 Lb.

All-welded straight-tube boiler delivers steam to electrically operated superheater with fan circulation of heated air

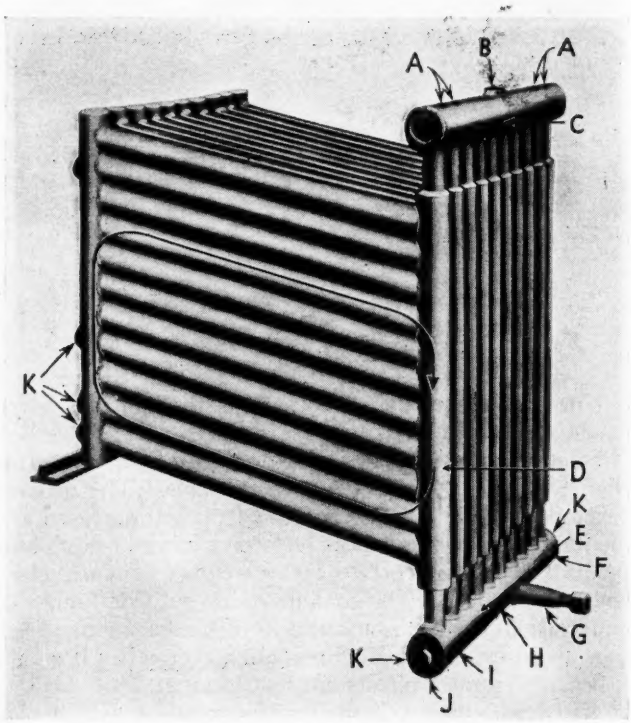


Fig. 1—The Boiler is Welded Throughout

A connections for steam gage, safety valve, water column, and water-level regulator; *B* steam outlet; *C* steam drum; *D* direction of water circulation; *E* mud drum; *F* water-level regulator connection; *G* stud for supporting boiler; *H* feed-water connection; *I* water column connection; *J* blowoff valve connection; *K* clean-out and inspection holes. (Also three holes in bottom of drum, not visible.)

By DARTREY LEWIS

Research Engineer
American Chain Company

A MINIATURE boiler with electrically heated superheater designed to deliver steam at 1,600 lb. pressure and 1,250 deg. F. has been installed by the Reading-Pratt & Cady Company in the research department of the American Chain Company. It will be used for the purpose of investigating steam valves and fittings for service at high temperatures and pressures.

At the time of writing, steam has been satisfactorily produced at 1,100 deg. and 1,600 lb. pressure. It is expected that there will be no difficulty when occasion arises in producing steam up to 1,250 deg. and 1,600 lb. It is believed this combination of temperature and pressure is the highest of any installations in the United States.[1]

All-Welded Water-Tube Unit

The boiler was made by the American Steam Automobile Company of Newton, Mass., and has a capacity of 250 lb. of steam per hour at 1,600 lb. pressure. It is a water-tube boiler with construction as shown in Fig. 1. The diminutive steam drum serves the purpose of a header between the sections of tubes. The water level is maintained at about two-thirds the height of the boiler. The seamless steel tubes are welded into headers provided with inspection plugs opposite the end of each tube (inspection plugs are not shown in Fig. 1).

The headers at one end are welded by means of smaller tubing into the mud drum and the steam drum, which are made from tubing the same size as the headers. The boiler has been tested with hydrostatic pressure of 3,000 lb. Danger of serious explosion in the event of failure is eliminated by the absence of any large drums.

Four burners with a total capacity of 1,000 cu.ft. of 530-B.t.u. city gas per hour are used. The steam pressure is automatically controlled by a G.E. pressure governor to within 25 lb. of the required pressure, which may be anything between 400 and 1,600 lb. This governor controls the gas supply through a solenoid gas valve. A safety valve set at 1,750 lb. was specially designed for the boiler by the Consolidated Ashcroft-Hancock Company.

A water-level regulator operates by expansion and contraction of a gently sloping steel tube on a level with the gage glass and joined to the steam and water sections of the boiler. The feed pump runs continuously; water not required by the boiler is bypassed through a valve operating by the expansion and contraction of the tube.

Protection against low water is obtained from a similar tube placed at a level below the water glass. Expansion of this tube makes an electrical contact operating relays which shut off the gas and the boiler feed pump. Condensate from the main plant boilers is used for boiler-feed water, and is filtered through Terry cloth, but not otherwise treated.

Superheater Is Electrically Heated

A superheater was specially designed and constructed by the research department of the American Chain Company for the Reading-Pratt & Cady Company, and incorporates some new ideas in design. The general arrangement is shown in Fig. 3. Steam from the boiler at 605 deg. and 1,600 lb. pressure is raised to a maximum of 1,250 deg. by passing through a single coil of $\frac{3}{4}$-in. double-extra-strong KA2S pipe. This coil was fabricated by the Babcock & Wilcox Company, and has six layers.

[1] Experimental boilers at Purdue University and Bayonne, N. J., have operated at 3,700 lb. and 5,000 lb. pressure, respectively, but at much lower temperatures.—Editor.

giving a total active length of 88 ft. The layers were made separately and welded together.

To avoid intercrystalline weakening of the KA2S tube by fuels containing sulphur, electric heat has been used. The heating elements are placed on all four sides of the furnace and separated from the KA2S coil by a square firebrick wall, thus preventing direct radiant heat. A fan made from stainless iron at the bottom of the furnace circulates air over the heating coils to the top of the furnace and then down through the KA2S steam coil. Steam passes through the coil in counter-flow direction from bottom to top.

In this way absolute uniformity of heating of the steam coil has been secured, thus eliminating the danger of weakness caused by overheated sections of the tube. Furnace temperature or steam temperature may be automatically controlled at will. The automatic features provided eliminate manual operation and give full automatic control of steam temperature and pressure independent of load.

General Layout and Manifolds

The general layout is shown in Fig. 2. At the extreme right is the water pump, next to the left is the boiler. The larger unit next is the superheater.

Two manifolds, each with five outlets, supply saturated and superheated steam for test purposes. The saturated-steam manifold is made from ¾-in. double-extra-strong pipe and the superheated-steam manifold from the same size KA2S pipe. Both manifolds are of all-welded construction. No gasket joints have been used in any of the piping carrying superheated steam. The manifold system was tested with 3,000-lb. hydrostatic pressure. It is insulated with 2-in. "Superex."

The test data shown in Table I have been obtained. Steam was measured by condensing and measuring the condensate. Temperatures of the steam were measured by thermocouples inserted in wells inside the steam manifolds.

TABLE I—DATA OF BOILER TESTS

Boiler:	
Period of test	1 hr.
Pressure	1,600 lb.
Steam produced	196 lb.
City gas	750 cu.ft.
Burners in use	3
Superheater:	
Period of test	1 hr.
Kw.-hr. consumed	42
Pressure drop	Not measurable
Steam passed	196 lb.
Temperatures, deg. F.	
Furnace gases:	
At top of steam coil	1,124
At bottom of steam coil	1,094
Steam coil:	
(Thermocouple welded on outside near exit end)	1,120
Steam:	
In manifold 1½ ft. from superheater	1,102
12 ft. from superheater	1,056

The amount of moisture was determined by a jet calorimeter using about 250 lb. of steam per hour and found to be 3 per cent. The following performance figures have been calculated:

The efficiency figure (Table II) would be increased by a higher output. In the test the steam was raised to within 22 deg. of the furnace temperature, so that considerable increase of steam output can be obtained if required. Somewhat higher boiler efficiency could probably be obtained with continuous operation with all four burners on. The manufacturers claim 83 per cent can be obtained with this type of boiler.

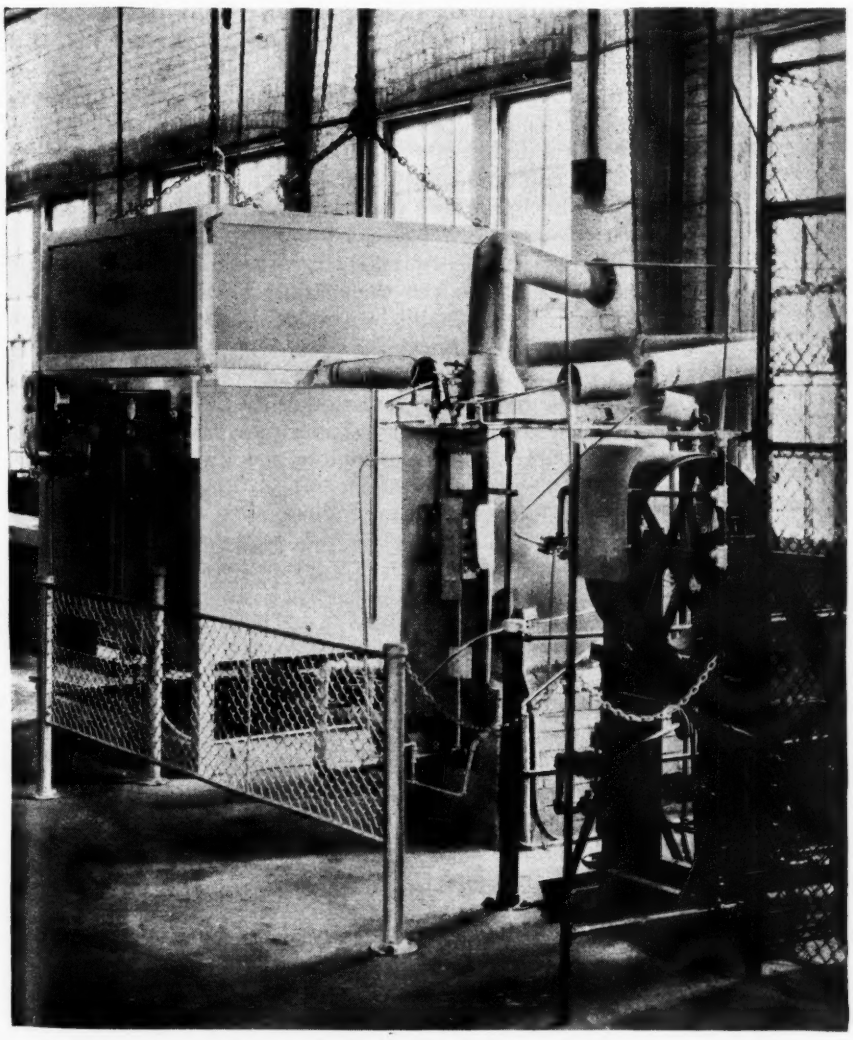


Fig. 2 (Right to Left)—Feed pump, gas-fired boiler, electrically heated superheater

Heat-Transfer Data

The total exterior surfaces of the boiler tubes plus half the area of the headers was 80 sq.ft. In one hour $1{,}109 \times 196 = 217{,}400$ B.t.u. was transmitted, giving a heat transfer of 2,700 B.t.u. per square foot per hour.

The exterior and interior surface areas of the superheater coil were 24.2 and 10.0 sq.ft. respectively. In one hour $422 \times 196 = 82{,}700$ B.t.u. was transmitted, giving 3,410 B.t.u. per square foot per hour for the exterior surface and 8,270 B.t.u. per square foot per hour for the interior surface. Average steam velocity through the superheater tube was 1,430 ft. per minute, and the air velocity measured at room temperature over the exterior surface was 1,100 ft. per minute.

Taking into account the low temperature differential between the final steam and furnace temperatures, these

rates of heat transfer are quite high and were undoubtedly influenced by the high density of steam at 1,600 lb. pressure (4 lb. per cubic foot), and the high velocity of air over the outside of the tube compared with ordinary furnace gas velocities.

An approximation of the ratio between radiation and convection in the superheater has been made by calculating the heat lost from the air in dropping 30 deg. F.

TABLE II—COMPUTED PERFORMANCE

Boiler:
Water at 70 deg. to 3 per cent wet steam at 1,600 lb. pressure (605 deg.) .....1,109 B.t.u. per lb. steam
City gas (530 B.t.u. per cu.ft.) .2,028 B.t.u. per lb. steam
Efficiency .....55 per cent

Superheater:
3 per cent wet steam at 1,600 lb. pressure to superheated steam at 1,100 deg., 422 B.t.u. per lb. steam,
0.124 kw.-hr. per lb. steam.
Power (1 Kw.-h. = 3,412 B.t.u.) 730 B.t.u. per lb. steam,
Efficiency $\frac{422}{730} \times 100$ .....58 per cent

while passing over the steam coil. From this calculation of 422 B.t.u. absorbed by each pound of steam 300 (71 per cent) was supplied by convection.

The maximum stress in the boiler at 1,750 lb. pressure (safety valve setting) was 6,700 lb. per square inch as calculated by Barlows' formula, and 5,900 lb. as

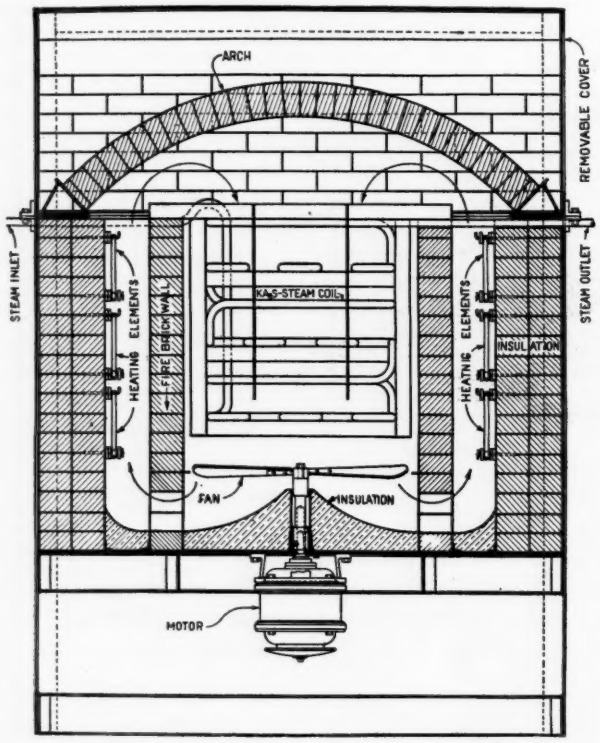


Fig. 3—Cross-section of superheater, showing circulation fan and walls to protect coils from radiant heat

calculated by Clavarino's accurate formula, in both cases allowing for the wall thickness being 12½ per cent less than gage size.

The maximum working stress in the superheater steam coil at 1,750 lb. pressure by Barlows' formula was 3,400 lb. per square inch and by Clavarino's 3,200 lb. These figures may be compared with creep stress for KA2S for 1 per cent creep in 100,000 hr. of 11,700 lb. per square inch at 1,000 deg. F.; 7,000 lb. at 1,100 deg.; 4,300 lb. at 1,200 deg.; and 2,400 lb. at 1,300 deg. It is thus seen that ample safety factors have been allowed in the design.

The Durability of Conveyor Belts

PRACTICAL INFORMATION on the durability of conveyor belts is given in a recent bulletin of the B. F. Goodrich Company. Following are comments obtained from this source.

Among the factors affecting the durability of belts are length, width, weight of material handled, heat, erosion and oil, abrasion and lift.

The longer the belt the less often it comes under the loading chute, where most of the wear on the cover takes place. Roughly speaking, the tonnage cost (of belt alone) on conveyors 500 ft. long is about double that of conveyors 250 ft. long.

Larger proportional tonnage may be expected of wider belts, since the volume of the load increases as the square of the width, while the wear is more nearly in direct proportion to the width.

Hot, oily or corrosive materials involve a more rapid deterioration of the belt cover, the rate of which is almost impossible to calculate. The average cost per ton for handling hot materials probably averages ten times normal costs. It is obvious that abrasive material will involve a higher belt cost per ton because of the more rapid wear of the covers. Lump material usually wears belts out faster than fine material. High lifts necessitate heavier fabric reinforcement and consequently higher unit cost per belt.

Loading approaches an ideal condition when the material is deposited on the belt at the same speed and in the same direction as the travel of the belt. The design of the chute and the regulation of the speed are among the most important factors governing the wear on the belt cover.

Money can be wasted or saved by intelligence in specifying the cover thickness. Thickness of top and bottom covers should be properly balanced to meet the conditions of service.

Decking, brushes and other devices to prevent materials spilling on the return side of the belt, or clinging to pulleys, are important factors governing the life of a belt. A few dollars saved in the design of a loading

TYPICAL RESULTS WITH COAL BELTS

Length	Width	Tons	Cost per 1,000 Tons
2,400	48	19,000,000	$0.76
148	30	655,861	0.57
1,775	48	4,400,000	1.70
1,043	42	7,919,000	0.70
190	36	4,540,000	0.09
33	21	5,633	16.70

chute or the installation of brushes may take its toll ten times over in the more rapid wear of the belt. A belt which travels faster than is necessary to handle its load cannot be expected to deliver as much tonnage as a belt well filled, since the delivery of a small load can wear the belt just as fast as a larger load.

Factors Under Control of Operator

Many belts are hopelessly damaged during installation. Maintenance of correct alignment of idlers and trippers avoids crooked running and edge injury.

Belts run too tight are doubly liable to injury. When idlers become stuck for lack of lubrication they wear sharp and cut the belt.

Uses for Sodium Aluminate

By coagulating suspended solids or sluage in the boiler, sodium aluminate prevents scaling and foaming. In external treatment it may be used to improve coagulation and chemical reactions, and for silica reduction. Data from typical plants illustrate the possibilities

By J. A. HOLMES*

THE SCIENCE of boiler feed-water treatment has progressed more in the last ten years than in all previous time. Mechanical equipment by which chemicals are proportioned or in which the water is softened were developed many years ago. Most of the recent developments in boiler feed-water treatment have been connected with the use of new chemicals and application and control of chemicals already in use.

One chemical that has been developed and has come into considerable use during the last ten years is sodium aluminate. This material was first introduced in the form of a solution containing a low percentage of sodium aluminate and high percentages of caustic and sodium carbonate. Since that time the material has been developed so that in some cases it can be furnished in dry form containing almost eighteen times as much sodium aluminate as the original product. As some so-called sodium aluminate solutions that contain an exceedingly low percentage of aluminate are still obtainable, it is important that the aluminate content be checked.

Use of sodium aluminate has found its largest application in boilers operating below 300 lb. pressure, where the percentage of make-up is frequently high, causing rapid concentration of solids in the boiler water. Therefore the treatment must be such that a minimum of incrusting solids enters the boilers and that those thrown out of solution in the boilers come down in a form that will not cause scale.

With internal treatment directly in the boiler, the sludge must be conditioned so that it will not bake on to the boiler metal as scale or cause foaming. With external water softening, the hardness in the softener must be reduced as much as possible and with no increase in soluble solids. A softer water is usually obtained with sodium aluminate. This eliminates the necessity of an after-treatment that is expensive when large quantities of water are used.

*Director of Service, National Aluminate Corporation.

In general, chemistry of water treatment is complex, as even the hardest of waters contains few solids. These exceedingly dilute solutions, and the many different salts present, complicate reactions and make it difficult for the chemist to determine just what happens. It is not the purpose of this paper to go into all the chemical details of sodium aluminate, but rather to point out a few of the main reactions.

The principle difference between the reactions of sodium aluminate and other common aluminum coagulants, such as alum or aluminum sulphate, is that the aluminum is contained in the negative radical Al_2O_4, and in this form reacts differently than when present as the positive radical Al, as would be the case with aluminum sulphate.

Sodium aluminate reacts with calcium in water to form calcium aluminate, but this is rather soluble and in the concentrations experienced in boiler feed water there is no appreciable reaction between sodium aluminate and calcium hardness. However, with magnesium there is a definite reaction for the formation of magnesium aluminate. Sodium aluminate also reacts with soluble silica in the presence of calcium or magnesium to form calcium or magnesium aluminate silicate. This material is similar to zeolite in its composition. These reactions make it possible to precipitate soluble silica in the presence of high alkalinities.

Internal Treatment

While it is generally recognized that softening of boiler feed water externally is more desirable than internal treatment, many plants are not in a position to have water softeners and must therefore treat internally. Sodium aluminate is used for internal treatment because it is easily controlled by simple chemical tests. It is most important to obtain coagulation of the suspended solids or sludge that will be thrown out in the boiler by treatment. Finely divided suspended solids tend to bake on the boiler metal as scale and increase

foaming tendencies. By coagulation the particle size of the boiler sludge is increased from a finely divided compact state to a large flocculent state. The sludge will then circulate more easily with the natural circulation of the water in the boilers. Being of a large flocculent nature, it will not collect in the steam bubble film and thus increase foaming characteristics.

For internal treatment only sufficient sodium aluminate is used to form complete coagulation and to insure silica reduction. Further softening reaction or excesses of alkalinity are obtained when necessary by the use of soda ash or phosphates.

The effect of coagulation on carryover is shown in Table I, the data being obtained at a rubber plant in Ohio. A decrease in soda ash and an increase in aluminate improved floc formation.

TABLE I — EFFECT OF COAGULATION ON CARRYOVER

Date	Dissolved Solids, Gr. per Gal.	Total Alk., Gr. per Gal.	Coagulation	Amount Carryover	Soda Ash — Lb. per Shift —	Sodium Aluminate — Lb. per Shift —
4–24–30	151	8.6	Poor	Heavy	25	20
5–21–30	145	8.9	Good	None	10	30

The effect of sodium aluminate on coagulation and silica reduction is shown by the date in Table II, obtained in the plant of a lumber company in Louisiana. The feed-water contained considerable natural sodium bicarbonate, so that the boiler water always showed low

TABLE II — EFFECT OF SODIUM ALUMINATE ON COAGULATION AND SILICA REDUCTION

Date	Suspended Solids, Gr. per Gal.	Dissolved Solids, Gr. per Gal.	Total Alk., Gr. per Gal.	Amount Scale, In.	Coagulation
12–9–29	5.9	46.1	18.0	¼	Poor
4–6–31	9.2	52.5	10.1	None	Good

hardness and high alkalinities. The silica content of the feed-water was separating out in the boilers in the form of a finely divided silica precipitate that settled on the boiler metal and caused scale. By simply changing the physical characteristics of the sludge in the boiler, by coagulating the fine particles, scale was eliminated.

Carryover and foaming can be caused from two materials present in the water, that in solution, and that in suspension, or sludge. The use of sodium aluminate for internal treatment is not recommended for carryover due only to dissolved solids, but rather for foaming due mainly to suspended solids and their influence on foam formation. Carryover caused by dissolved solids usually can be prevented by concentration control.

External Treatment

Sodium aluminate is used in conjunction with lime and soda ash primarily to improve coagulation, improve chemical reactions and for silica reduction. Being alkaline in nature, sodium aluminate works with the lime and soda ash, which also are alkaline, rather than

TABLE III — REDUCTION OF HARDNESS AND RESULTANT ALKALINITES BY USE OF SODIUM ALUMINATE

Date	Grains per Gallon — Hard.	Pht.	M.O.	Pounds per 80,000 Gal. Tank — Lime	Ash	Iron Sulphate	Sodium Aluminate
11–5	1.2	4.4	5.5	140	76	18	..
11–5	0.7	2.7	4.8	117	48	..	20

in opposition to their reactions, as do the acid coagulants aluminum and iron sulphate, nor does it add soluble sulphates or require extra lime and soda ash treatment, as they do. Table III shows the effect of sodium aluminate in reducing the hardness of the treated water and the resultant alkalinities obtained.

Some interesting results obtained by water treatment are shown in Table IV. Without the use of sodium aluminate the plant was experiencing a calcium sulphate scale. Sodium aluminate was used so that complete reactions would be obtained in an overtaxed hot-process softener. Only sufficient aluminate was used for coagulation. Sulphate scale was eliminated, but with this

TABLE IV — SODIUM ALUMINATE ELIMINATES CALCIUM SULPHATE AND SILICATE SCALE

Date	Grains per Gallon — Hard.	Pht.	M.O.	SiO_2	Aluminate, Lb. per M	Scale Type
11–13–29	1.2	0.7	1.4	0.63	0	Sulphate
6–13–30	0.2	3.4	5.1	0.79	½	Silicate
9–15–30	0.2	3.0	4.5	0.50	½	None

elimination the percentage of silica in the scale increased. By increasing the aluminate treatment, thereby reducing the amount of silica in the feed-water, the silicate scale also was eliminated. This demonstrates the necessity of watching all factors in water treatment, as the elimination of one type of scale may produce another type that may be even less desirable.

In some instances when the ratio of the hardness of the feed water and silica are within certain limits an after-treatment of sodium aluminate to feed water that has been presoftened with lime, soda ash and sufficient

TABLE V — RESULTS FROM AFTERTREATMENT IN BOILER

Sample	Sol. Silica, Gr. per Gal.	Total Alk., Gr. per Gal.	Scale	Aluminate
Treated	0.7	4.5	.....	½ lb. per M gal.
Boiler	4.8	104.0	1/16 in. 35 per cent silica	No aluminate after-treatment
Boiler	2.0	110.8	None	Aluminate after-treatment

sodium aluminate to obtain coagulation and finished chemical reactions is more economical for the prevention of silica scale than to increase the dosage of aluminate in the softening plant. Table V shows results obtained by an after-treatment with sodium aluminate directly in the boilers.

Filtration

In some plants it is desirable to filter water ahead of zeolite softeners. Ordinarily, aluminum sulphate is used for this purpose. At times of high turbidity the alum

TABLE VI — IMPROVING FILTRATION BY ADDING ALUMINATE TO ALUM

Date	Alum, Gr. per Gal.	Aluminate, Gr. per Gal.	Turbidity — Raw, P.p.m.	Filtered, P.p.m.
4–6	2.0	0	15.0	2.0
4–8	1.0	0.5	15.0	0.0

reactions are not completed and poor filtration results. The addition of a small amount of sodium aluminate along with the alum improves coagulation by greatly increasing the speed of the reactions. Table VI shows the result of such a treatment.

To overcome the difficulties of feeding chemicals ahead of filters, sodium aluminate has been compressed into ball form so that it may be fed through a receptacle similar to an alum pot, thus eliminating the need of pumps and proportioning devices.

The use of sodium aluminate is not recommended as a "cure-all," but it does have definite values when used properly and for the purposes for which it is best fitted. Its use should be under the general supervision of those thoroughly familiar with the reactions involved and with water treatment in general. Aluminate products should be obtained with a thorough knowledge of the sodium aluminate content, the stability of the material furnished, and with the intention that standard practices of water treatment shall be followed during the use of sodium aluminate. If the foregoing points are given consideration many plants can use sodium aluminate to advantage.

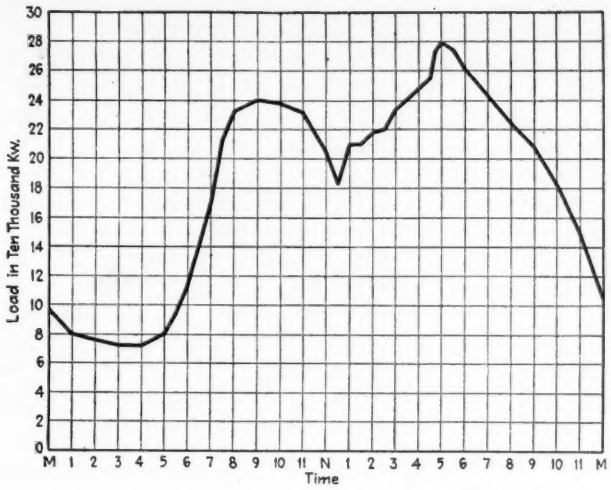


Fig. 1 — Typical daily load curve of a central station

By A. G. CHRISTIE
Professor of Mechanical Engineering
Johns Hopkins University, Baltimore

The Load-Duration Curve

The trend in power station development is definitely toward means whereby more kilowatt-hours can be secured per dollar of total cost. Since special equipment to carry peak loads leads to such low-cost production, one may expect this phase of system design to receive greater attention in the future

EVERY ENGINEER recognizes the need of a daily load curve which shows the output of an electric station at every hour or half-hour during the day. This load curve gives an indication of the demands of the power system at all times and assists in predicting the probable load changes on the days to follow. The curves are also studied to note the changes in the peak load from time to time and thus to permit predictions to be made of future trends. The area under the load curve represents, to a certain scale, the kilowatt output of the system and is useful as an indication of station performance. Any unusual changes in the general form of load curve demand study and explanation on the part of the engineers in charge. Fig. 1 shows such a daily curve. Daily load curves vary from day to day and from season to season.

When attempting to combine daily load curves in such a manner as to get a true picture of the station or system performance over a month or over a year, the problem is difficult if one tries the ordinary method of averaging to get the desired average daily load curve. One large system cut its daily load curves out of stiff cardboard for a whole year. These were stacked consecutively back to back and mounted in a frame. The result was interesting as indicating seasonal, holiday and Sunday variations and maximum annual peak. However, it was confusing if one tried to judge the loading for a whole year or the relation of all loads carried to one another.

A single curve can represent all loads throughout the year. This is generally known as the "load-duration" curve. One of these for a station serving a residential section with a large lighting load and with 30.4 per cent load factor is shown in Fig. 2. The load-duration curve is easy to construct. It has been used for many years by some American engineers and should be more widely employed on every system. The curve is plotted with kilowatt load as ordinates and total hours per year as abscissas.

Each point on the curve indicates the total number of hours per year that the load has not been less than the number of kilowatts represented by the scale of that point. The daily load curves, or station log sheets, are first taken and the average output for each hour or half-hour of the twenty-four hours is noted. Then a set of sheets is prepared, with a space for each unit load (say for each 1,000 kw. in the case of a large system) and a record is made on these sheets of each hour or half-hour that a certain load has obtained on the system. When the daily loads for the whole year have been so recorded the load-duration curve can be drawn. First the highest hourly load for the year is plotted for the first hour. The next highest load for the next, or, if this load obtained for several hours, the corresponding number of consecutive hours after the first. All other loads are plotted in the order of their descending magnitudes, with cumulative time for the base of the curves.

For example, suppose the maximum hourly peak load on a given system for the whole year was 99,000 kw. This is plotted in the division representing the first hour. The next highest load was 95,000 kw. and also lasted for only one hour. This is plotted in the division representing the second hour. The third highest load of 92,000 kw. lasted a total of three hours. This is plotted for the fifth hour of the year. The next highest load of 90,000 kw. lasted for four hours and is plotted for the ninth

hour of the year. The same process can be followed for all lesser loads. The last and lowest hourly load of the year will thus be plotted at the end. The total hours per year, namely, 8,760, will be covered in this way.

A smooth curve drawn through the points that have been plotted will give the load-duration curve for the particular system. The area under the curve represents approximately the kilowatt-hours to a given scale and may be used to check the yearly output computed by other

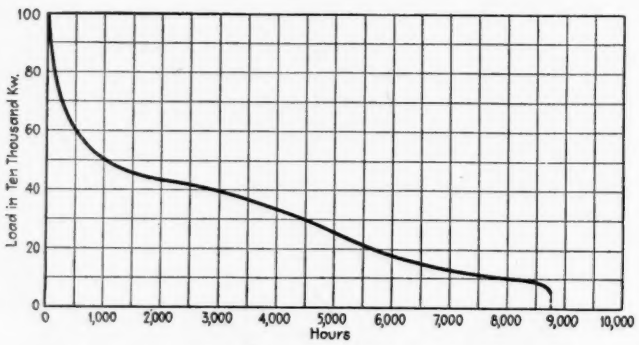


Fig. 2—Load-duration curve for power system with 30.4 per cent annual load factor

means. The annual load factor is represented by the ratio of the area under the curve to the total area up to a horizontal line drawn through the maximum load. The steeper the load-duration curve the lower will be the load factor. On the other hand, the flatter the load-duration curve and the less it diverges from the flat curve at maximum and minimum load the higher will be the load factor. The importance of load factor as a measure of sound engineering design and of cheap power production should encourage the preparation of load-duration curves for all power systems and a study of them to determine means to improve load factors.

The load-duration curve gives a true picture of the extent and total time of the highest and lowest loads. A study of the curves of different years shows whether the system load has increased more rapidly in the light-load period or on the peaks. The slope of the curve indicates whether the load factor for the year is increasing or decreasing. These studies assist in accurately gaging trends of load growth.

Year-to-Year Picture of Load Building

The growth of a system over a period of years is shown by the load-duration curves of Fig. 3. A survey of these curves shows that peak load grew at a less rapid rate than did average load during 1928. The opposite conditions prevailed in 1927, when the average system load grew less rapidly than the peak. Such a set of curves will indicate in a forceful manner, to an executive, the true results from year to year of his load-building efforts in off-peak hours and will also show the growth of the minimum as well as the maximum loads.

Management has long recognized the desirability of filling in depressions in the load curves and of building up night and other off-peak power loads. It has devoted much attention to the lower right-hand section of the load-duration curve. These studies have been very fruitful in improving load factors and operating conditions and have well repaid the effort that has been expended on this work. However, any particular plant that can carry the peak load has obviously no difficulty in providing capacity to carry the night loads.

In many systems there has been a tendency for the peak loads to grow faster than the average load of the whole system, and this is particularly true where the greater proportion of the load is lighting and domestic heating. The peak load plus a certain reserve fixes the capacity that must be installed in the generating station. This also is an index of the necessary investment on which the service must pay fixed charges.

The load-duration curve presents data from which a true picture of peak loads can be drawn. For instance, in Fig. 2 the annual load factor for that portion of the load-duration curve in excess of 75 per cent of the maximum peak is 0.2 per cent. The annual load factor for load in excess of 50 per cent of the maximum peak is 2.91 per cent. Annual load factors for other portions of the system load can be similarly analyzed.

Generating the Peak Load

Such a study of load-duration curves led, in another paper[1], to the following conclusions in regard to peak-load capacity in a generating system (1) equipment intended for peak-load service on a system must be installed at the lowest possible first cost; (2) and economy of peak load equipment can be sacrificed to secure low initial cost. The first rule is evident from a consideration of the few hours of service during the year and the small output during those few hours. Only low-cost equipment can be justified. The second follows from a consideration of the small amount of power to be generated by such peak-load equipment. It will be obvious that the cost of each kilowatt generated on peak loads consists predominantly of fixed charges, with relatively

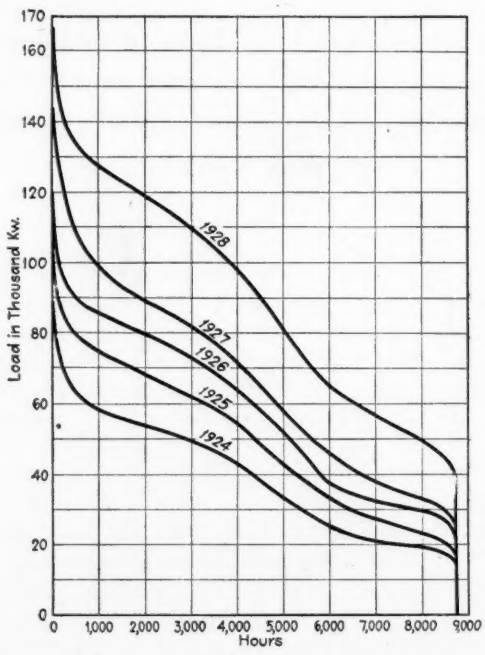


Fig. 3—Load-duration curve showing growth of a power system over a period of years

small charges for fuel, labor and maintenance. Hence full attention should be devoted to maintaining the lowest fixed charges possible, and if these lower costs can be secured by less economical equipment, economy should be sacrificed. In other words, economy in fuel consump-

[1]The Peak Load Problem in Steam Power Plants, *Mechanical Engineering*, Dec. 1928.

tion is not a leading factor in selecting equipment for peak-load service.

The following calculations indicate the correctness of these rules: Assume a plant having a load-duration curve as shown in Fig. 4, with 200,000-kw. peak-load capacity and an annual load factor of 51.4 per cent for the year. Suppose two 25,000-kw. turbines are installed to carry that portion of the load in excess of 75 per cent of the maximum annual peak. These turbines at 2.6 per cent annual load factor will generate 11,388,000 kw.-hr., or an average of 227.8 kw-hr. for each kilowatt

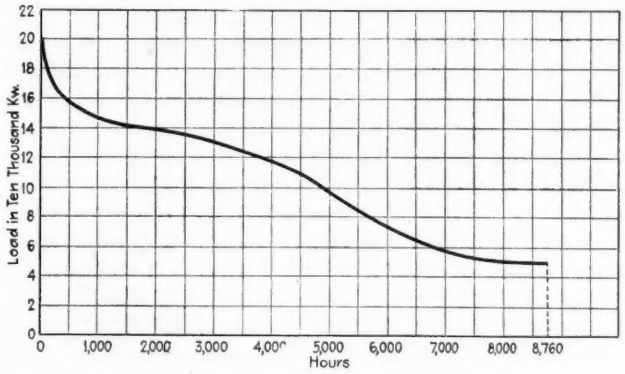


Fig. 4—Load-duration curve for a system with 51.4 per cent annual load factor

of machine capacity. If 12,500 B.t.u. coal is available costing $4 per ton of 2,000 lb. and if 1.8 lb. of coal per kilowatt-hour is allowed for operating on these peak loads, the cost of fuel per kilowatt-hour will be 0.36c. Suppose the cost of this section of the power plant complete for 50,000-kw. peak-load capacity was $80 per kilowatt. With interest 6 per cent, taxes and insurance 3 per cent, depreciation 6 per cent, the annual fixed charges per year, of 15 per cent, would be $12 per kw. of capacity. The total cost per kilowatt-hour is $\frac{12}{227.8} + .0036 = \$.0563$ or approximately $5\frac{1}{2}$ cents.

Now suppose that high boiler ratings were permitted with some sacrifice of boiler efficiency and that a turbine of high overload capacity with a sacrifice in efficiency and in vacuum at full load were installed at a cost of, say, $70 per kilowatt of capacity. The fuel consumption can be assumed to have increased 33.3 per cent to 2.4 lb. per kilowatt-hour. The fixed charges, totalling 15 per cent, will now be $10.50 per kilowatt of capacity and the total cost per kilowatt-hour is $\frac{10.50}{227.8} + .0048 = \$0.0509$. The resulting saving is $(0.0563 - 0.0509) \times 11{,}388{,}000 = \$61{,}495$ per year. It has been assumed in both cases that labor, maintenance, supplies, and banking costs on boilers remained practically the same in both cases. Low first cost should therefore be the prime objective in the design of peak-load plant, and economy as measured by fuel consumption should be a minor consideration.

Increasing Plant Capacity

The load duration curve enables one to estimate the size of unit which will best fit into the system when an addition to plant is under consideration. For instance, a system with an annual load factor of about 51.4 per cent, such as Fig. 3, presents two possibilities for additional capacity. One can add a new unit for peak-load service to handle the top portion of the curve or a new unit for base load service, which would cause the older equipment to be shifted to services at lower annual load factors. The production costs of the units now on the system and their performance with either of these two new units would have to be closely studied to determine which new plant would be the more economical. In America the tendency has been to install base-load units for all new plants. This may not always lead to power generation for the whole plant at lowest cost, especially where annual load factors are moderate. In Europe the trend has been to give more and more consideration to the problems of peak loads.

This article has indicated certain of the possible uses of the load-duration curve and the methods of preparing and analyzing such graphs. Such curves are coming into more general use each year as their value and helpfulness are more generally recognized. It is to be hoped that more engineers will be encouraged to prepare and study load-duration curves of their own systems, for much useful information may be obtained from such efforts.

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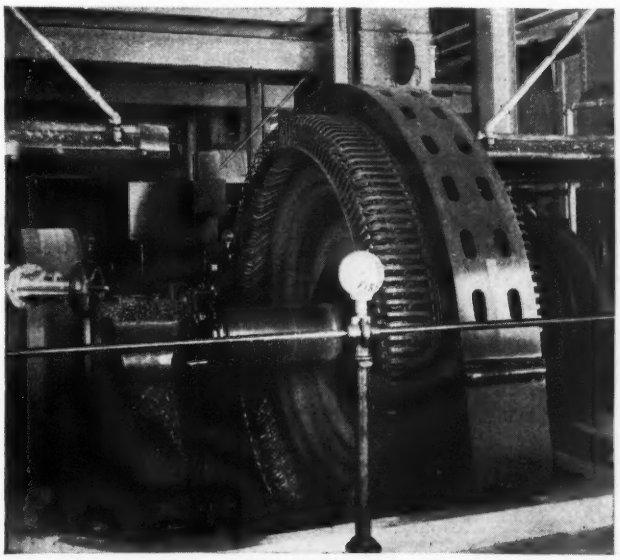
Large Synchronous Motors Use Part-Winding Starting

FIVE synchronous motors, each rated at 3,500 hp., and the largest in use for grinding pulp, are installed in the new paper mill of the Maine Seaboard Paper Company, Bucksport, Maine. The motors run at 240 r.p.m. and drive two-magazine pulp grinders through a double shaft extension.

These motors are started by the part-winding method. Their stators are wound with two parallel circuits, and in starting first one of the circuits and then the other is connected to the line. No reactors or auto-transformers are used. This starting method with frequency-responsive relays provides smooth starting with minimum line disturbance for these large motors, supplied by Electric Machinery Manufacturing Company.



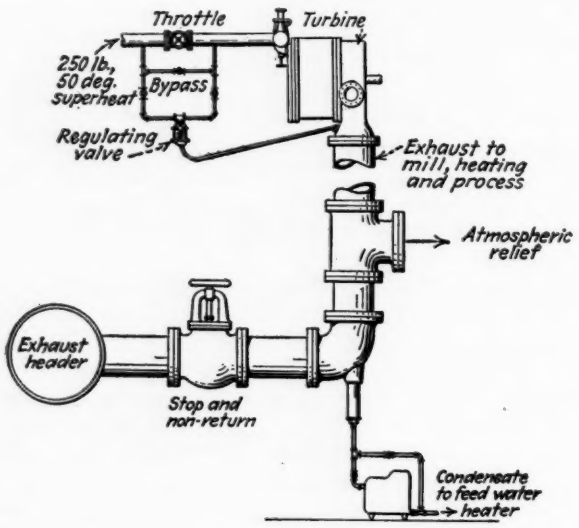
One of five 3,500-hp. synchronous motors driving pulp grinders

PRACTICAL AIDS

TO OPERATION

Control of Cooling Steam To Synchronous Condenser Unit

A TEXTILE MILL operating two 1,500-kw. non-condensing turbines in conjunction with a power system recently found it advisable to float one of these units on the line as a synchronous condenser during periods when the power demand in the mill was low. The operators, after



Arrangement to control cooling steam supply

having some difficulty with the last stages of the turbine and the inboard bearing overheating, were overcautious in the amount of cooling steam admitted. As the turbine was run this way for periods of several days at a time the loss from the excessive use of high-pressure steam was considerable.

A simple arrangement was decided upon to give positive control of the cooling steam automatically regardless of the pressure or temperature of the steam admitted to the first stage of the turbine. The temperature expansion element set in the exhaust line of the turbine was adjusted to operate at 260 deg. F., which is several degrees above the normal operating back-pressure temperature. If overheating is caused by the turbine-blade friction as a result of insufficient cooling steam, the rise in exhaust temperature will cause the regulator to admit more cooling steam.

A low-pressure non-return valve was placed in the exhaust line between the turbine and the exhaust header. A simple receiver led down from the elbow to a low-pressure trap and this took care of any condensate that might form before the check opened. An atmospheric relief valve was connected before the non-return and in the particular case described was set to open at 8 lb. gage pressure. The regulating valve was of a special type having the pressure acting under the diaphragm. With this arrangement a relief valve of proper capacity should be provided in the exhaust system.

Milford, N. J. H. M. SPRING.

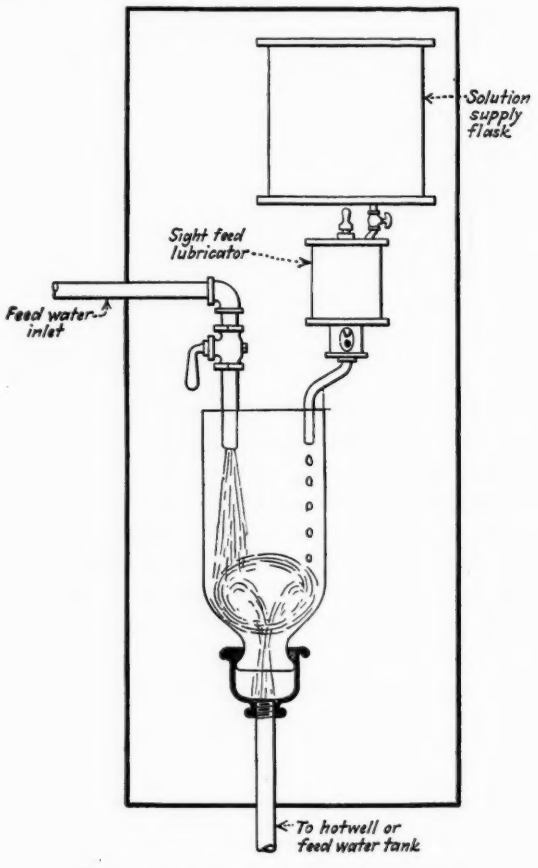
Sight-Feed Solution Mixer for Water Treatment

IN SMALLER PLANTS where feed water has to be treated to prevent scale, a solution is generally put into the hotwell or feed-water tank at definite intervals. In many plants this practice becomes haphazard, and therefore inefficient. A simple and inexpensive but efficient arrangement can be made from odds and ends around the plant.

As shown in the illustration, a reducing coupling is screwed on to the feed-water supply to hotwell or feed-water tank, as the case may be. Any convenient-sized chemical bottle, with bottom cut out, is placed in the coupling upside down and packed with asbestos. The feed-water supply is now placed about 1 in. into the bottle and to one side. An ordinary drip-feed lubricator of convenient size is placed in the opposite side in the same manner. A supply flask or tank to hold a week's or month's supply, as required, is connected to the drip-feed lubricator inlet as shown.

It will readily be seen that the feed water will make a whirlpool effect in the neck of the bottle, thereby making a natural mixer to the drops falling from the drip-feed lubricator. Also this arrangement gives a sight feed-water gage, perfect sight mixer and a sight feed solution observer.

Montevideo, Uruguay. E. KERR.



Arrangement of visible solution mixer

CURRENT COMMENT

Conservation of Energy

THE "Conservation of Energy" question asked in the Dec. 29 number of *Power*, as to what happens to the resilient energy contained in a spring when the spring is dissolved in acid, is an old one, and one which has received various answers at different times. The true answer probably is that the stressed metal is less resistant to chemical attack than is unstressed metal, and that the resilient energy appears in the form of excess thermal energy while the metal is being dissolved.

No explanation based on the reappearance of the resilient energy in the form of increased temperature in the spring immediately upon coiling can possibly be correct. Any destructive work, that is, work which results in permanent change in shape, immediately reappears in the form of heat, the heat being more or less equivalent in amount to the energy absorbed; but this energy cannot later be regained in the form of work. As shown by Joule and by Lord Kelvin many years ago, the stressing of metal within the elastic limit has an entirely different effect. Compressive stresses result in a very slight rise in temperature, and tensile stresses in an equally slight *drop* in temperature, the amount depending on various thermodynamic factors. As the resulting temperature differential equalizes across the thickness of the thin strip of which the spring is made, there is a slight loss of energy, but this will be less than 1 per cent of the original 100 ft.-lb. As suggested in the expanation given in *Power* the remainder of the energy reappears in the form of heat in the acid solution.

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Why Not Pregasify the Fuel for Diesel Engines?

REFERRING to the article on preheating diesel fuel oil, which appeared in the Dec. 1, 1931, number of *Power*, it is beyond doubt that introducing the fuel into a compression-ignition engine in a hot vapor or gas form will reduce the ignition lag practically to zero. By controlling the admission we can effectively control the combustion, and a predetermined cycle can be followed. Combustion can be made to begin as gradually and the engine can be made to run as smoothly as desired. Diesel engines could be speeded up considerably if the ignition lag did not limit the rise.

The ignition of the fuel accumulated in the combustion space during the ignition lag makes it impossible at present to control the first part of the combustion. If a great portion of the fuel charge is introduced before ignition takes place the early part of the charge may precipitate on the walls and escape combustion entirely, or all of the accumulated fuel may burn at once, giving rise to intolerable pressures and combustion shocks. Cutting out the ignition lag would eliminate all this.

It is logical to get around this difficulty by pretreating the fuel. In other words, to prepare it externally in such a way that it is fit to burn without delay. The means suggested are heating, vaporizing or both.

The temperature has a great effect on the ignition lag. The chart shows how the ignition lag decreases with increasing temperature, as determined by Neumann. If the oil is preheated to a temperature of, say, 800 deg. F. the ignition lag becomes negligible.

Regarding the effect of vaporizing the oil, opinions disagree. It no doubt promotes better mixing of fuel with air.

According to measurements of Wollers and Ehmcke, the ignition temperatures of gasified oils are 300 to 700 deg. F. higher than the ignition temperatures of the same oils in liquid form. It is commonly accepted that in diesel engines an appreciable evaporation of the fuel before ignition does not take place. Whether or not the fractional evaporation which does take place is responsible for initiating combustion is not clear. How much benefit one gets from vaporizing or gasifying the fuel before injection is uncertain, but the effect of high temperature is certainly beneficial.

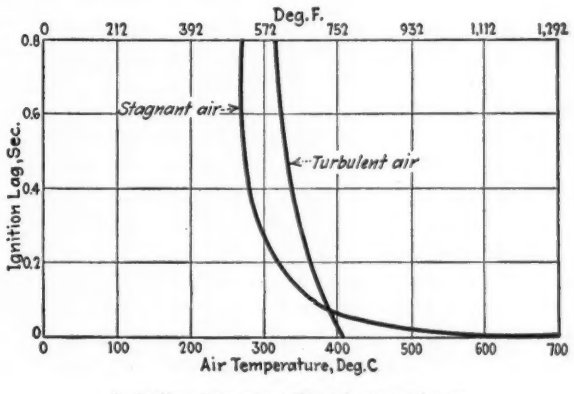
Heating and vaporizing should be considered together because it is hard to imagine external heating without vaporization, or vice versa.

The practical problem is twofold: first, heating, vaporizing and, eventually, gasifying the fuel; second, forcing the vapor or gas into the cylinder.

If the compression and introduction of a combustible gas were a simple proposition, gas engines would generally work under the diesel principle, which permits higher compression ratios and better fuel economy. Instead of mixing it with the air before admission, the fuel gas would be introduced at the end of the compression stroke and permitted to ignite and burn at the rate it is admitted.

Another method of forcing vaporized or gasified fuel into a cylinder would be by its own vapor pressure or gas pressure, developed by heating. Tests made by the National Advisory Committee for Aeronautics (Report No. 371) show that at 850 deg. F. the vapor pressure of fuel oil is only 150 lb. per square inch and, therefore, very high temperature would be required to produce the vapor pressure of 1,000 lb. necessary for blasting in the fuel. Only volatile liquids like ether, benzol, or alcohol possess sufficient vapor pressure for such utilization.

Whether the vaporized fuel be introduced by its own pressure or pressure imparted by a compressor, the liquid fuel must be heated to a temperature above the critical point of the heavy ends of the fuel, probably above



Injection lag at various temperatures

1,000 deg. F. Heating oil to such high temperatures will cause it to crack even under pressure. Then the opposite, polymerization, will take place. The products are too uncertain and probably not best fitted for charging the engine. Residues and coke deposits, which cannot be evaporated at all, will accumulate on the container wall and will make the maintenance of the heating unit cumbersome.

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Why, When and How to Make Load Tests on Motors

THE VALUES of periodic motor surveys, on which C. O. H. requested information in the Dec. 15 number, are many. By this means the efficiency and power factor of the motors, the loading of the feeders and the power costs of each operation can be determined. Plants usually are adding loads to the existing one. If a motor survey has been made the size of the motor for the new load may possibly be determined by comparable loads. Often a motor is under- or over-loaded or of the wrong type. In this case, when purchasing additional equipment a proper motor may be ordered for the existing load and the old motor can be connected to the new load. Frequently the investment in plant equipment is reduced in this manner.

Load may be added to the existing feeders that may be near their capacity before the addition of the new load. In alternating-current systems, by means of motor-test data, the existence of a motor on a feeder that is causing a poor power factor can be noted. By interchanging the motors to raise the power factor the additional load may be carried on the feeder without other means to improve the power factor. On direct-current systems an underloaded motor operates at reduced efficiency and an overloaded motor may have high maintenance.

Motors today are made in numerous types for various starting duties, operating cycles, etc. If some of the plant motors are not adapted to their loads they may be interchanged with others which are. The motor survey also shows which motors can be interchanged, knowing, of course, the types and duties. Also, in the case of a motor failure without a spare on hand the motor survey data tell which motors in the plant can be substituted. From the available motors in the plant one can usually be temporarily removed from its present location.

Another advantage of motor testing is to check the mechanical condition of connected equipment. For example, suppose a manufacturer states a machine requires 10 hp. and a motor test indicates it is taking 15 hp. Assuming the manufacturer is correct in his statement, it would be well to check the alignment of bearings, gears and other parts of the machine to determine whether there is undue friction that adds to the load. Also, if duplicate motor-driven units are installed a motor test will compare the units and show whether the loads are equal—as they should be in performing the same work—or whether one machine is in need of repairs or alignment. I had a case in which duplicate centrifugal pump units did not have equal motor inputs. An examination of the pump of the unit taking excessive power showed worn and leaky impeller rings. When repairs were made to this pump the power load was reduced to approximately that of the other pump motor.

Another advantage of motor surveys is that if the voltage is read when the motor is tested improper voltages will be noted.

For direct-current systems the instruments required are an ammeter with different shunts for the proper range of current and a voltmeter having the proper scales. For alternating-current systems I prefer two single-phase indicating wattmeters of 5-amp., 110-volt capacity to use on motors of different voltages, such as 220, 440 and 2,300. These wattmeters are used with the proper portable current and potential transformers of the variable-ratio type. A voltmeter is also desirable. By the use of the two wattmeters the total power input is read regardless of the unbalancing of the load or the voltages. The ratio of the wattmeter readings readily gives the average power factor from the equation

$$\text{Tangent of the angle of lead or lag} = \sqrt{3}\,\frac{P_1 - P_2}{P_1 + P_2}$$

in which P_1 is the larger reading of the two wattmeters and P_2 is the smaller. The cosine of this angle is the power factor.

By means of the wattmeter and voltmeter readings the average current may be calculated. Where a continuous record for a period is desired a graphic wattmeter is useful. Motor surveys should be made annually.

St. Louis, Mo. VICTOR N. FRIEDMAN.

Burning Boiler Oil in Diesels

I WAS quite interested in the discussion concerning the economies of burning cheap boiler oil in diesel engines which appeared in the Feb. 2 number of *Power*.

Assuming that the engines are designed so that satisfactory operation can be had on the heavier grades of fuel and complete combustion is possible when using 11-deg. Baumé oil, the temperature of fuel to the injection pumps must be a minimum of 115 deg. F. and the maximum will be the point where the fuel-injection pumps become gas-bound.

The engines will have to be started and stopped on light oil, and therefore it will be necessary to install an auxiliary fuel tank for this light oil. Minor changes must be made in engine adjustments, such as changing the number of atomizer plates and the timing of the fuel injection. The changes necessary will be found from a careful study of indicator diagrams.

After changing from 30 to 11 deg. Baumé fuel, one should expect the liner and piston ring wear to be increased and a slight increase in the maintenance cost of the entire fuel system. Other maintenance costs should not be affected. I assume that under present operation liner renewals are necessary every five years and piston ring renewal every year, and would estimate present maintenance costs of liners, piston rings and fuel systems at $3,000 per year. If 11-deg. Baumé oil is used this figure will be doubled, or will total $6,000 per year.

Assuming that the plant is now operating on a basis of 13,000 B.t.u. per kilowatt-hour, the fuel bill, using 30-deg. Baumé fuel at 52c. per gallon, would be $66,700 per year. If 11-deg. Baumé fuel at 3.25c. were used the fuel bill for one year would be $38,500. Adding $3,000 to this figure for extra maintenance costs, the total will be $41,500, giving a new saving of $25,000 per year.

Daytona Beach, Fla. J. WYLLY KECK.

Engineering Studies Essential in Economic Hydro-Plant Operation

Abstract of a paper presented at the fall meeting of the Hydraulic Power Committee, Pennsylvania Electric Association by Carroll F. Merriam, Pennsylvania Water & Power Company, Baltimore, Md., in which attention is called to some of the ways that engineering talent released because of inactivity in construction work may be employed to good advantage to improve the economy of operation

THIS is a time when economy, which may unfortunately take the form of shortsighted practices, is stressed. Expenditures will perhaps be eliminated that in normal times would be considered justified by progressive administration. These economy programs carried to their extremes have led in many cases to serious reduction of engineering forces. Attempts may be made to justify this action on the grounds that there is little construction being done, and consequently there is little need for engineers, technicians and draftsmen. It is the purpose of this paper to call attention to some of the ways in which the talent released by inactivity in construction, can be effectively employed. It seems logical that this technical ability should be turned to the much emphasized subject of economy.

First consider the prime mover in the hydro plant. The most accurate source of information regarding the way it accounts for the water placed at its disposal is the formal acceptance test. The keen interest shown on the part of both manufacturer and purchaser is generally conducive to securing as high a degree of accuracy as is permitted by practical considerations. These tests are often costly as they become more elaborate, and as more precautions are taken to secure reliable results. As a general rule a manufacturer meets his guarantee so that although on the whole the tests serve the purpose of discouraging the sale of equipment on absurd claims as to efficiency, nevertheless taken individually it may appear to the purchaser an expensive luxury, when the results allow him no reduction in equipment price.

Under these circumstances it is especially important that the purchaser should derive incidental information as a by-product. It is frequently possible that this information may result in a saving that will much more than repay the entire cost of the test. Inasmuch as acceptance test data are commonly used as a basis for measurement of discharge through the plant, as determined from observations made by the operating force, care should be taken to make note of all data necessary to convert test results based on net head to gross or station head. This means particularly that the readings regularly taken from hour to hour should be observed in the same manner during the tests, even though more accurate means are employed for the test itself.

The next suggestion is to find some way to obtain useful information when formal tests are lacking. Considerable attention has been given of late to the development of index methods. Exceedingly useful information may be derived without the large amount of expense required in making absolute measurements of either input or output even though the results are not comparable with those of other units. These methods consist primarily of employing some indication of input and output which will give consistent rather than precise results.

Indicating Amount of Discharge

One common method of indicating the amount of discharge is by water columns connected to carefully selected piezometer openings. The three common methods of locating these openings are: (1) At points where the cross-section of the conduit may be different, Venturi principle; (2) at points in the scroll case where the static pressure may be different, Winter-Kennedy principle; and (3) at points on a stay vane where one piezometer is subjected to the impact of the water, Peck principle. So far it seems imposible to say to what extent the results will be affected by velocity distribution but these methods appear to give results within commercial limits of accuracy. The electrical output may likewise be indicated by secondary standards or even by timing the revolutions of the disks of the ordinary watthour meters.

One of the interesting variations of these index methods is a proposal to employ them for determining the correct relation between gate opening and blade angle for Kaplan wheels. If successful application can be made, it would greatly assist in narrowing the limits for which it is necessary to make regular acceptance tests to determine the envelope of the efficiency curves for the various blade angles.

Curves for Acceptance Tests

The curve commonly required for acceptance tests, usually based on net head, is of little value to operating men. First this curve must be redrawn, referred to station head, and with output expressed as kilowatts rather than shaft horsepower. This requires that observations be taken during the test to determine the site loss, losses through racks, water passages, etc., in fact everything necessary to translate from the net head to the gages used by the operators.

With this done, the plant superintendent has before him a picture that in the first place shows him how the unit compares with others in the same plant. From the information he can decide the order in which the machines should preferably be placed on the line during insufficient flow to get the largest number of hours of use from the more efficient units. Secondly, an idea is obtained of the suitability of the unit to carry the type of load that it is required to generate. For example, if the curve is broad, that is with a wide range of high efficiency, the unit may be well adapted to maintain frequency, and should be equipped with a sensitive governor having small inherent speed drop. If, on the other hand, the curve is peaked, similar to that of a propeller turbine or of a high-speed francis type, the governor should be set to have a large inherent speed drop. The unit will then tend to hold a nearly constant load while others that are better suited to carry the swings will do the regulating. In cases where the efficiency drops off rapidly, it may pay to block the governor with the load limit to prevent inefficient operation.

Planning Load Schedules

Accurate test results are essential for planning economical load schedules for machines of different characteristics. It has been proved mathematically (see F. R. Rogers and L. F. Moody, "Interrelation of Operation and Design of Hydraulic Turbines," Section 2, *Engineers and Engineering*, March 10, 1925, pages 5-10) that the most efficient combination is secured when all machines carry such loads that any one can take on an additional kilowatt of load for the same additional consumption of water as any other. If all machines in the plant are alike, maximum economy can be secured when each carries equal loading. The problem

however, becomes more complicated when there are several types of machines in the same plant. There are various means by which the correct loading can be accomplished automatically, all of which have been amply described in the literature of several manufacturers and the technical press (see *Transactions*, A.I.E.E., Vol. 50, March, 1931, and also N.E.L.A. "Governor Report," Publication No. 13, December, 1930).

The theoretically correct number of machines for a given load is not difficult to determine and consists of drawing by a simple method of construction the discharge vs. horsepower curves for various arrangements of units on the line. These curves will show inefficient zones which should be avoided in station loading. These are particularly pronounced where there are but few high-speed wheels in a plant, especially when all the wheels are of equal capacity. The load dispatcher should be cognizant of the limitations so that as far as possible the plant will not be operated in these inefficient zones.

Means for controlling the unit's performance from the point of view of efficiency during low flow, and capacity when water is spilling over the dam offers an opportunity to make large economies in operation. During high flow, capacity is of paramount importance and some supervisory system should be used to insure that all of the units are coming up to standard.

The progressive company is constantly confronted with economic problems both electrical and hydraulic. As plants become located more closely together on the same river and the principle of overlapping head becomes more commonly used, it is desirable to take careful observations of water-surface elevation under all combinations of discharge through the plants, pond elevation and river flow. It is only with these data carefully coordinated in the form of curves that intelligent solutions can be had to the questions which will arise concerning the desirable elevation of the intermediate pools.

In many plants the tailrace canal which was sufficient in the earlier days may prove inadequate as the plant grows beyond the expectation of the original designers, and as circumstances arise that they did not foresee. As a plant is used more and more for peak service, the average rate of discharge during hours of operation increases so that channel improvements which could not formerly be justified become interesting.

Increasing the Head During High Flow

Another interesting field for investigation is the possibility of increasing head during times when the river flow exceeds the capacity of the plant. This problem may take several forms such as development of the ejector turbine, the admission of flood water to the lower part of the draft tube, the use of the Thurlow back-water suppressor or by the construction of diversion walls, dikes, etc., to prevent back flow of the flood water into the tailrace. Each plant presents its problem, but an interesting feature is that by the use of head increasers we are in effect breaking down the limitation imposed by the inherently high efficiency of the hydraulic turbine which is often said to permit little opportunity for future improvement in performance.

Another method of securing greater output during times of abundant flow is to change the distribution of the flood waters over the spillway so that the tailrace will have less interference. In many developments there are interesting possibilities, particularly if the overflow can be confined to more remote side of islands in the stream. It has been demonstrated that the gates farthest away from the power house may be opened with less effect on the reduction of head.

A variation of the idea of preventing as much interference from overflow as possible is the scheduling of gate operation during time of flood so that the river can be flushed during the night valley, thus allowing as much of the flood flow as possible to pass during the time that reduction of head causes no loss in output.

Chipping Runner Buckets

For the sake of increased capacity at high flow, chipping of the runner buckets is frequently done. Unfortunately at the present time we have but little information regarding the effect on efficiency. If this could be determined possibly by index methods, it would be a very nice economic problem to determine to what extent the units in a given plant should be chipped in order that a plant would be provided with some units unchipped which could have high efficiency, and others which would give higher capacity during high flow but would be used as little as possible during low flow.

The manipulation of pondage gives rise to a number of problems, particularly where many plants are under the control of the same company. The problem is further complicated when there is overlapping of head because when the loss at one plant is practically entirely made up for by the gain at others, water can be drawn from storage with but a slight loss in economy.

Economical to Spill Water

It may seem paradoxical that it is economical to spill water over a fixed-crest dam during low flow, but it has been realized that a small amount of spilling gives the plant a higher head during the day by starting out with a higher maximum forebay. The loss in energy can be balanced against the gain resulting from the use of the water not spilled at a higher average head. No rules can be laid down as there are many factors involved which make each problem distinct. Shape of load curve, length of spillway and river flow play important parts. In addition to the economic gain it is highly desirable from the point of view of sanitation to allow some water to pass over the dam daily to prevent pools from becoming stagnant.

An important contribution on the part of the West Penn Power Company is the work of J. E. Stewart and E. T. Schuleen (see "Pennsylvania Electric Association Hydraulic Power Committee Report," 1928, page 7, and *Monthly Weather Review*, May, 1929, page 186, concerning the prediction of floods). By being able to foresee the coming of high water, it is possible to draw down the pond level in advance and thus make use of water that would otherwise be wasted. There are many interesting possibilities of adapting their method to other plants even though the conditions may be different.

Service Performed by Hydro Plants

We must not limit our ideas of economy to the saving of kilowatt-hours alone. There are other services that a plant performs in addition to the generation of energy, and careful study must also be given to increasing its accommodation to the system, through saving in peak capacity prepared for, and in carrying load swings to relieve the rest of the system from inconvenience and loss of economy. It should be determined whether or not the hydro plant can perform the service desired more cheaply than other plants on the system, and if so it should be used.

Not commonly associated with economy, but still having important bearing on the wellbeing of a company is safety. Watchfulness in avoiding accidents and attention to operating hazards should not be relinquished in any effort to reduce operating expenses. Along with safety should be emphasized the value of good housekeeping and maintenance of equipment which is too frequently allowed to go by the board when expenses are reduced. A plant in poor condition is generally an indication of unhealthy financial situation, and is apt to affect seriously a company's credit position. It shows furthermore a lack of engineering appreciation on the part of the management.

It is particularly essential that the engineers and the men who have this appreciation of the value of true economy in the sense of wise and prudent application of wealth, should assert their influence to avoid such mistakes as have been common in the past during times of depression, that penny-wise and pound-foolish policy that has led to false economy. Progressive-engineering effort is not a good-times luxury, but an essential element in the stability of the industry.

▼

In the table of equipment accompanying the article "Swift & Company Revamp Steam Supply at Chicago," Feb. 2 number, the turbines driving the forced-draft fans were erroneously listed. These fans are driven through reduction gears by Sturtevant turbines running at 4,500 r.p.m. Also the arches and walls on No. 5 boiler were supplied by the Bigelow-Liptak Corporation.

The Trend of Power Plant Design in Germany

Status of high steam pressures and temperatures and the Benson and Loeffler boilers. Combustion air temperatures with stokers and pulverized fuel. High-speed turbines. Handling peak loads*

THE LARGEST boiler units in Germany are those installed in the "West" power station of the Berlin Electricity Works. Their capacity is 265,000 lb. per hour normally, with a guaranteed maximum of 330,000. The heating surface is 25,800 sq.ft. each. They are stoker-fired.

High Pressures and Temperatures

In the Langerbrugge[1] (Belgium) steam plant a high-pressure turbine is operating as a unit with the high-pressure Benson steam generator. All of the steam from the generator passes the high-pressure turbine and goes back to the boiler to be reheated. The reheated steam goes to the station main and from there to the main prime movers.

The high-pressure turbine operates the feed pump for the high-pressure steam generator. This feed pump is also driven by a motor-generator which can supply the necessary power in case the output of the high-pressure turbine is not sufficient, or can generate electric energy if there is excess power available from the turbine.

This high-pressure plant with Benson steam generator of 220,000 lb. steam per hour normal capacity went into operation in fall 1930.

A Benson marine boiler[2] of 45,000 lb. per hour capacity was built by the Hamburg shipbuilding firm Blohm & Voss as licensee of the Siemens-Schuckertwerke, A.G., and is in regular service between Hamburg and Dutch East India on the freighter Uckermark of the Hamburg American Line. The outstanding feature of this plant is that the boiler generates more than four times as much steam in the same space as the old marine-type boilers and weighs only 100 tons compared with 160 tons for the old-type boilers.

The reason that high-pressure steam plants are still rare in Germany is the economic condition which prevents the erection of larger plants. Many projects for high-pressure steam plants are under way. If economic conditions improve, a considerable increase of high pressure steam plants will take place.

Superheat temperatures up to 950 deg. F. are in use, the highest temperatures occurring in connection with Loeffler boiler. In this type of boiler the conditions are more advantageous with superheat temperatures. Even at initial superheat temperatures of 950 deg. F., reheating cannot be avoided, because of the moisture content of the steam in certain stages of the turbine. With Benson steam generators it is not necessary to go up to such temperatures, and initial temperatures and reheat temperature of up to 850 deg. F. are used.

For valves and fittings, steel of tensile strength of 37,000 to 71,000 lb. per square inch with 20 per cent elongation is used. Piping is made of steel of 64,000 to 78,000 lb. tensile strength with 18 per cent elongation.

Combustion Air Temperatures

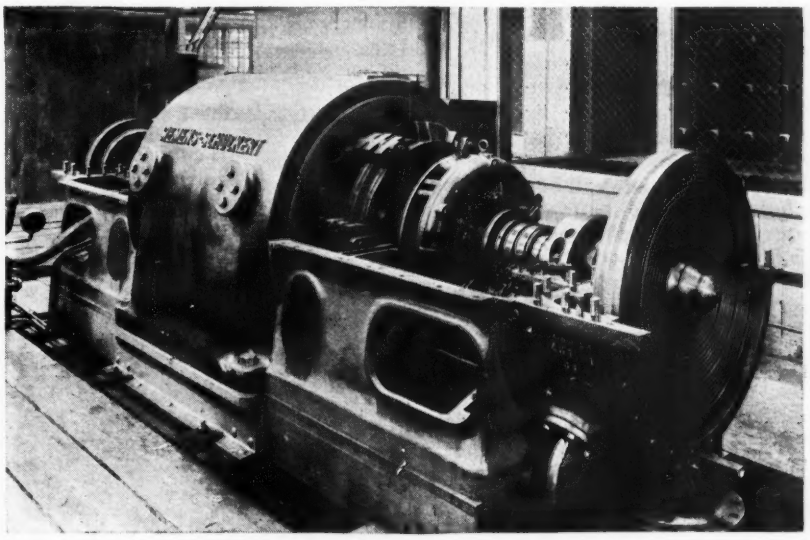
Combustion air temperatures depend on the type of firing and the type of fuel. For stokers 450 deg. F. seems to be too high. Tests were made with brown coal up to 570 deg. F., but the temperatures have been reduced to 450 deg. F. In connection with traveling grates, the combustion air temperature has not been raised above 300 deg. F. When firing pulverized fuel in a well-cooled combustion chamber the temperature of the combustion air is limited only by the material of the air preheater. Temperatures of 750 deg. F. are normal in connection with Benson steam generators.

The longitudinal seams of boiler drums up to 500 lb. pressure are almost all welded. In the "West" power station the drums are 40 ft. long and welded. Welding of pipe lines also gains ground.

The Siemens-Schuckertwerke has built the largest turbine for 3,000 r.p.m. for a Belgian power station. Its capacity is 64,000 kw. or 80,000 kva. Machine capacities of 100,000 kva. at 3,000 r.p.m. are under consideration. The development of Ljungström turbines goes in the same direction. It is not expected to go above 30,000 kw. at 3,000 r.p.m.

Ljunström turbines are gaining ground in utility and industrial power stations. For the latter application radial machines have been built to use more efficiently small amounts of back-pressure steam. Condenser housings are welded in many cases. Two or more flow arrangements are preferred to one.

Peak-load turbines are built either for variable admission pressure with special control gear for operation with steam accumulators or as turbines for constant admission pressure with provision for large overload facilities. In Brussels an accumulator station is in the course of erection similar to that at Charlottenburg.



Ljungström turbine for a European industrial installation

*Information for this article supplied by Mr. Gleichmann, head of the steam engineering division, Siemens-Schuckertwerke, Berlin. Digest prepared with the cooperation of Karl A. Mayr, New York City.

[1]See *Power*, Dec. 29, 1931.

[2]See *Power*, Dec. 15, 1931.

City of San Francisco Places Large Motor Order

A CONTRACT for nine 1,000-hp., 1,200-r.p.m., and three 900-hp., 1,200 r.p.m. synchronous motors and their control was recently awarded the Electric Machinery Manufacturing Co., Minneapolis, Minn., by the City of San Francisco, Calif. The motors will be used to drive high-head centrifugal pumps on the Corral Hollow pipe line of the Hetch Hetchy water project.

READERS' PROBLEMS

VOLUME OF AIR FOR AIR LIFT—*In estimating the amount of air required to operate an air-lift pump, our engineers employ an equation* $V = \frac{h}{C \log \frac{H + 34}{34}}$ *with C having various values. No one seems to know how this is derived and assumes it is a mere rule-of-thumb. Can you show me the basis of the formula?* H.S.

The derivation of this formula is as follows: Let H be the submergence in feet of water in which event the maximum absolute pressure to which the air must be compressed will be $H + 34$ in term of equivalent water head. In this 34 ft. is the head due to atmospheric pressure. The compressor intake pressure is 14.7 lb. abs., or a 34-ft. hydraulic head. The ratio of the compresor discharge and suction pressures, in terms of absolute hydraulic heads, is $R = \frac{H + 34.}{34}$

The energy in the air that can be gained by expansion back from the receiver pressure to atmospheric, assuming isothermal conditions, will be $EP_sV_s\log_e R$, where P_s is the absolute suction pressure in pounds per square foot, V_s the suction air volume, or volume of free air after expansion, and E is the efficiency of the air lift.

The work of lifting the water is

$$Work = 8.33\ Q\left(h_1 + \frac{V^2}{2g}\right)$$

Setting the two equations equal, we have $8.33\ Q\left(h_1 + \frac{V^2}{2g}\right) = EP_s\ V_s \log_e R$

By transposition and substitution and setting Q equal to unity.

$$V_s = \frac{h}{585\ E \log_{10} \frac{H + 34}{34}}$$

In place of 585 the constant C is used, this being 585 times the efficiency of the lift, which latter varies with the well depth.

INFLAMMABILITY OF REFRIGERANTS—*Which of the present-day refrigerants are inflammable?* M.L.

A series of tests by Kinetic Chemicals, Inc., revealed the following facts, some of which have long been known:

Sulphur Dioxide (SO_2): Sulphur dioxide does not decompose below 2,000 deg. F., but oxidizes slowly in the presence of moisture.

Dichlorodifluoromethane (CCl_2F_2): Dichlorodifluoromethane is thermally stable up to 1,000 deg. F. It is non-flammable, but when brought into contact with a flame that portion which is simultaneously heated to the high temperature of 1,000 deg. F. and exposed to the action of water vapor and oxygen is decomposed with the formation of HCl, HF, CO_2, and, under certain conditions, traces of $COCl_2$.

Methylene Chloride (CH_2Cl_2): No data are available on the thermal decomposition of this refrigerant. Under the conditions given for the flame decomposition of dechlorodifluoromethane, it decomposes to give HCl, CO_2 and some $COCL_2$.

Methyl Chloride (CH_3CL): Methyl chloride, when heated, begins to decompose noticeably at 500 deg. F. It is flammable, and when burned produces water, CO_2, and HCL, but no $COCl_2$.

Carbon Tetrachloride (CCl_4): Carbon tetrachloride begins to decompose at 900 deg. F. In the presence of a flame it is partly converted to HCl, CO_2, and some $COCl_2$.

Carbon Dioxide (CO_2): Carbon dioxide will not decompose noticeably below 2,000 deg. F. It is non-combustible.

Ammonia (NH_3): Ammonia, when heated alone, begins to decompose into nitrogen and hydrogen at 500 deg. F. In the presence of air it can be burned to water and nitrogen.

Propane (C_3H_8): Propane is thermally stable below 500 deg. F. When ignited it burns readily, giving CO_2 and water vapor.

Isobutane (C_4H_{10}): Isobutane is thermally stable below 500 deg. F. It is flammable and will give CO_2 and water vapor when burned.

▼ ▼ ▼

Location of Atmospheric Relief Valve

Summary of Readers' Opinions on the Previous Question

IN STUDYING the power plant of a contemplated office building the point has come up as to where the atmospheric relief valve for the engines should be placed. The engine room will be 632 ft. below the exhaust outlet on the roof. Back pressure in the heating season will be 5 lb. and in summer that due to the atmospheric. Will there be any difference in the engine back pressure between locating the relief valve on the roof or in the engine room? Ignoring the pipe friction, what will be the pressure at the engine when the relief valve is open during the summer? G.R.

▶ ALL THE ANSWERS received failed to cover the question fully. In the first place, friction losses cannot be ignored, even though the questioner so stipulated. In the second place, the matter of velocity head was neglected by all. The answers, nevertheless, are interesting as showing how engineers differ in their approach to a prloblem.—EDITOR.

IN WINTER the back-pressure at the engine must be kept at 5 lb., as evidently the heating installation was designed for this pressure. Here the following cases are to be considered:

Case 1. Relief valve in engine room.

(*a*) All the exhaust steam is used for heating. In this case the relief valve is closed. The valve will be set for 5 lb., which will be the engine's back pressure.

(*b*) Some excess exhaust steam is escaping through the exhaust pipe filling the same.

The pressure of this steam in the pipe will be equal to atmospheric, its weight much less than that of the air, the latter weighing 0.0828 lb. per cubic feet (20 deg. F. assumed), the former 0.03732. The difference in the weights of air and exhaust steam will result in a stack action, with the tendency to keep open the relief valve at a pressure less than for what it was set originally. In this case the valve will open when the pressure under the valve is 5 lb., but once open it will stay open as long as the pressure under the valve is over 4.8 lb. and not 5 lb. This is for the reason that the pressure over the valve will amount to — 0.2 lb. (0.4 in. of mercury vacuum) due to the stack action, for the difference between the pressures under and over the valve must be 5 lb. to keep it open, in this case the sum of 4.8 lb. pressure and 0.2 lb. of vacuum.

In other words, the relief valve will close only after the pressure under it has dropped to 4.8 lb., but open again only when the pressure reaches 5 lb. [But the loss of pressure due to velocity head must not be forgotten—Editor.] This lagging in the closing of the valve will cause a fluctuation in the heating steam pressure between 4.8 and 5 lb., and a waste in exhaust steam every time the valve opens, while the pressure will drop from 5 lb. to 4.8 lb. This could be eliminated by activating the relief valve by a membrane instead of a weight, with one side of the membrane connected to the relief pipe under the valve and the other to the open atmosphere, and adjusted so that the valve would close whenever the pressure dropped to 5 lb. The valve itself must be balanced so that the pressure difference on its two sides will neither open nor close it. If all the exhaust

steam is used for heating all the time and some live steam must be added the case described above will not occur.

Case 2. Back pressure valve on roof:

When all the exhaust steam is used for heating, the relief valve must be closed. The pipe up to the roof will be filled with exhaust steam at 5 lb. pressure, which is still lighter than air, 0.0491 lb. per cubic feet, consequently it too will produce a stack action. To compensate for this the valve must be set to 5.15 lb. to obtain 5 lb. in the engine room, from where the heating system is supplied. [But the pressure at the valve is less than that in the header—Editor.]

When some excess exhaust steam is escaping through the exhaust pipe the relief valve opens. In summer the relief valve will be kept open whether in the engine room or on the roof. The escaping exhaust steam will fill the pipe and produce the stack effect. Assuming an outside temperature of 80 deg. F., the back pressure will be about 0.15 lb. less than atmospheric, equivalent to nearly 0.3 in. of mercury vacuum.

It will be more practical to locate the relief valve in the engine room, on account of better accessibility.

ANDREW A. BATO.

East Orange, N: J.

THE ATMOSPHERIC RELIEF VALVE had best be placed on the roof. When set at 5 lb. pressure, the back pressure at the engines, 632 ft. below the valve, ignoring pipe friction, will be 0.216 lb. higher, due to the weight of steam in the pipe. The atmospheric valve can be set to compensate for this if deemed necessary. If the valve is in the engine room the same back pressure must be maintained to have 5 lb. pressure in the heating system, and a separate exhaust stack will be necessary.

In the Summer with the relief valve open the back pressure at the engine will be 0.167 lb. less than atmospheric, due to the 632-ft. column of steam in the stack being lighter in weight than a similar column of air. Air weighs 0.075 lb. per cubic foot and steam at atmospheric pressure 0.037 lb. per cubic foot. [When steam is in motion one cannot employ the pressure that exists under static conditions.—Editor.] Pipe friction would, of course, have to be considered.

A. L. FREULER.

St. Louis, Mo.

ASSUMING a differential pressure of 5 lb. required to operate the valve, the back pressure on the engine will be 5 lb. plus the pipe friction on both sides of the valve. Assume, further, the same pipe size for either location.

To pass a given quantity of steam at atmospheric pressure will involve a higher velocity, and consequent greater friction loss, than to pass the same quantity at 5 lb. pressure; therefore the engine back pressure will be greater if the valve is located near the engine. However, for any reasonable pipe size this difference will be small, and may be compensated for by the setting of the relief valve. [But the question assumes a 5-lb. back pressure.—Editor.]

Answering the second question: the static head due to a column of steam 632 ft. high is 0.16 lb. per square inch for atmospheric pressure, and 0.14 lb. for steam at 5 lb. gage. [There is never atmospheric pressure when steam is flowing.—Editor.]

The valve should be located in the engine room for two reasons: first, liability of freezing if placed on the roof; secondly, to make it more accessible for regular inspection and test. The exhaust side of the valve should be fitted with an open drain provided with a water seal but no shut-off valve. This to insure against accumulation of leakage above the valve.

B. C. STEWART.

Birmingham, Mich.

THE BEST LOCATION for the atmospheric relief valve in this installation is near the top of the exhaust riser, just under the roof. The valve should be equipped with remote electric control to provide quick and easy regulation from the engine room.

If the valve is placed at the top of the exhaust riser this line will also serve as a riser for the heating system, and will therefore save 632 ft. of large pipe. This saving in piping cost will more than balance the cost of remote control. The large size of the exhaust riser will also serve to equalize the pressure throughout the heating system.

During the heating season there will be no difference in the engine back pressure regardless of where the relief valve is located, since the valve will be set to maintain a back pressure at the engine just sufficient to produce satisfactory heating.

In Summer the back pressure on the engine will be independent of the location of the relief valve. During this period the back pressure on the engine will be just equal to pipe friction in the exhaust riser plus the pressure drop through the open relief valve. Since these two items will be the same regardless as to whether the valve is at the top or bottom of the riser, the back pressure will be the same in either case. [But the velocity heads will be different, which means that the pressures at the base must be different—Editor.]

Ignoring the pipe friction, the back pressure on the engine in Summer will be equal to the pressure drop through the wide-open valve. The amount of this pressure drop depends upon the size of the valve and the quantity of steam exhausted.

P. J. BERRY,

The Frederick H. Mason Co.

Detroit, Mich.

WITH THE relief valve on the roof and set at 5 lb. the actual pressure at the engine exhaust will be 5 lb. plus the weight of a 632-ft. column of steam at the density corresponding to 5 lb. gage. [This depends upon where the vacuum gage is located.—Editor.] This column pressure amounts to about $\frac{1}{5}$ lb. (0.218), so the total pressure will be 5.218 lb. per square inch. With the relief valve open during the Summer the pressure at the engine will be slightly less than atmospheric, since the density of the steam is only about one-half that of the air. The difference in pressure of a column of air and one of steam at atmospheric pressure each 632 ft. high is 0.171 lb. Hence the pressure at the engine exhaust will be $\frac{1}{8}$ lb. per square inch less than atmospheric. In this connection the atmospheric pressure is that considered at the engine level and not on the roof, as the atmospheric pressure 632 ft. above the engine is about $\frac{1}{5}$ lb. per square inch less than at the engine. [If this reasoning were correct, even in Winter when the relief valve opened the pressure would drop below atmospheric.—Editor.]

General practice is to be place relief valves as nearly as possible to the engine or chamber to be relieved, for the following reasons:

1. The operator can note whenever the valve functions and take the necessary steps to prevent further overload. Also the valve is more accessible.

2. Operation of the valve can be checked easily with the gages and any discrepancy noted and corrected. It is good practice to operate these valves manually once a week to insure their working properly.

3. If the valve is placed at such a great distance from the engine it may fail to operate at the proper time because it will take a pressure wave in the long steam line an appreciable time to reach the valve. The pressure waves may also be very complex and cause erratic operation.

4. With the valve at the top of the building, the connecting pipe line will be under pressure during the heating season and an appreciable loss from condensation will occur.

The best arrangement of valves and piping would be the relief valves on the engines and the discharge from the valves connected to the atmospheric exhaust line at a point just above the "cut-out" valve in the exhaust line leading to the roof.

T. A. SOLBERG.

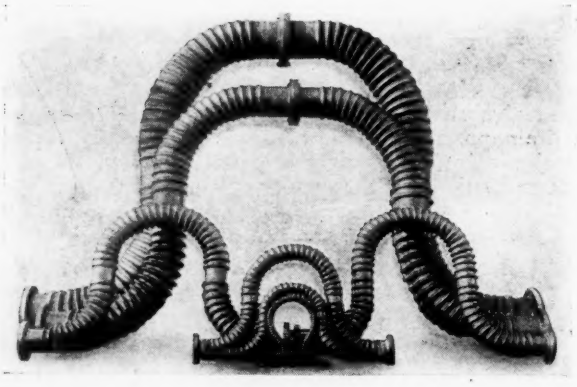
Annapolis, Md.

A Question for Our Readers

IS THERE any reason why I cannot pump well water, and circulate it through radiators to cool our building in summer? With 60-deg. water, how much heat will each radiator remove per square foot, assuming the room air is cooled from 80 to 72 deg. F.? C.C.M.

Suitable answers from readers if received promptly, will be paid for when published

WHAT'S NEW IN PLANT EQUIPMENT



Group of corrugated bends made by Aiton process

Corrugated Steel Pipe Expansion Bends

THE ACCOMPANYING ILLUSTRATION shows the "Aiton" corrugating process as applied to steel pipe and tubing in the form of expansion bends. Developed in England, corrugated bends of this type have been used extensively in that country and Europe for power plant, marine and special services. They are now being introduced in this country by the Standard Piping & Fitting Company, 49th and Gray Aves., Philadelphia, Pa.

By virtue of the corrugating process these bends are said to give maximum flexibility in all directions, permitting safe connections in close quarters and where vibration and weaving are a factor.

Although the company expects it will be about July 1 of this year before a complete line of these bends will be produced in its own shop, present needs are being filled by importing bends and attaching American Standard flanges at the Philadelphia plant.

Precision Control Added to Continuous Blowdown System

IF THE CONTROL of concentration in boiler water is to be accurate and blowdown losses held to a minimum, the blowdown must be accurately controlled. To fulfill this requirement the Elgin Softener Corporation, Elgin, Ill., has applied the Eckel precision control to the discharge end of its continuous blowdown system. Controlling the blowdown in this way, after it has been cooled, obviates trouble from flashing of blowdown water into steam and the subsequent wear and tear due to the abrasive action of the impurities.

Any one of any number of boilers can use the same heat reclaimer, and each boiler can be operated according to individual requirements, so that the concentration in each boiler is controlled with precision regardless of the fluctuations of the load. Since the control regulates the rate of blowdown from each boiler at any time, and permits it to be definitely known, adjustments for the correct requirements of each boiler can be made.

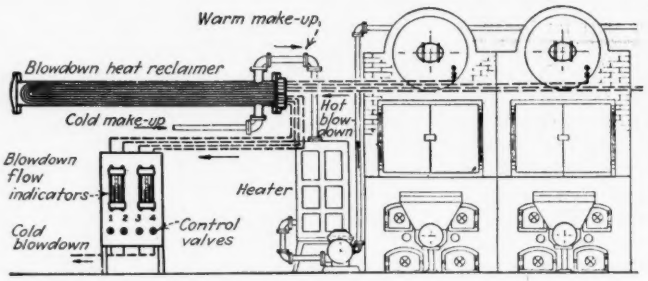


Fig. 1 — Hook-up of Elgin continuous blowdown system with Eckel precision control serving four boilers

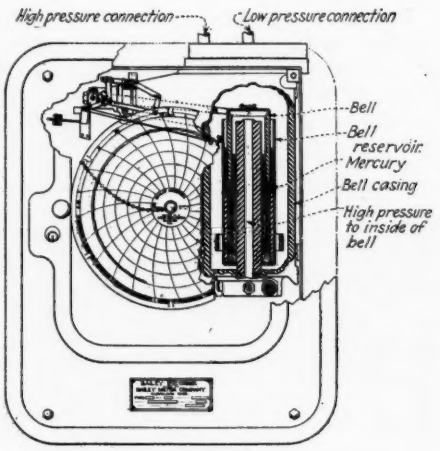
As indicated in the accompanying illustration, a control panel carries the flow gages and one control valve per boiler. Each gage indicates the flow of blowdown in gallons per minute directly from its respective boiler, and, by means of the valve for this boiler, the blowdown is regulated by hand according to the gage. The seat, disk, stem and packing nuts of any valve may be removed from the front of the panel without interfering with the pipe connections or other connections at the rear. The gages may be cleaned without shutting off the flow of blowdown. Loss of mercury is prevented by a stainless-steel check which is an integral part of the gage. Pyrex gage glass is used.

The blowdown lines, usually of ¾- or 1-in. size, are brought out from each boiler and carried directly to the heat reclaimer. A gate or globe valve installed in each line and close to the boiler is used for shut-off purposes. Individual lines are then brought out of the reclaimer and carried to the control panel, where they are connected to vertical pipes forming integral parts of the panel.

Leaving the boiler at high temperature, the blowdown water flows to the heat reclaimer, where it passes through copper U-tubes proportioned to provide ample area for the flow at the correct velocity and the necessary distance of travel to abstract the heat from the blowdown. From the reclaimer the cooled blowdown water from each boiler passes to the rear of the panel through the individual control valve and orifice, leaving the orifice to blow to the discharge line. Blowdown water entering the heat reclaimer at a temperature of 400 deg. F. will discharge to the sewer at a temperature within 10 deg. of the entering feed water.

Boiler-Water Level Recorder

THE boiler-water level recorder illustrated operates on the difference in level obtained by making two connections to the water column or boiler drum, one connection being made to the water space and the other to the steam space, where a constant water head is maintained in the connection by means of a steam-condensing radiator and a reservoir. The variable-head, or water-space, connection is applied over a mercury-sealed bell and the constant-head connection is applied to the inside of this bell. As the boiler-water level rises or falls the mercury-sealed bell falls or rises, and this motion is transmitted to the recording pen by a forked



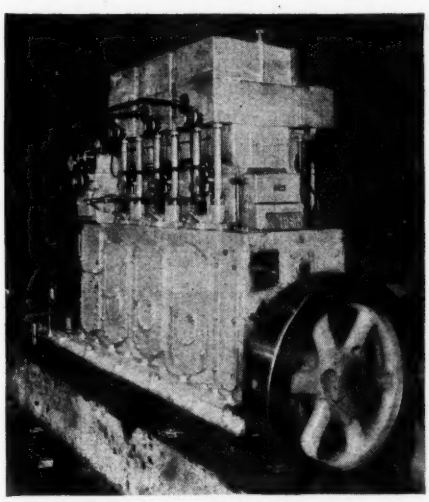
Bailey boiler-water level recorder

lever and a spindle which turns in pressure-tight bearings. A reversing linkage is employed between the spindle and recording pen so that the pen moves upward as the water in the boiler drum rises and moves downward as the water level drops.

The recorder may be incorporated with a feed-water flow meter to record the two related factors on one chart, and remote indicators or recorders operating from the main recorder can be placed at other points if desired. Types and combinations are available in all pressure standards up to 1800 lb. The instrument is put out by the Bailey Meter Company, 1036 Ivanhoe Road, Cleveland, Ohio.

Four-Stroke-Cycle Solid-Injection Diesel

THE four-stroke-cycle solid-injection diesel shown in the illustration has been brought out by the Vivian Gas Engine Works, Vancouver, B. C. While this



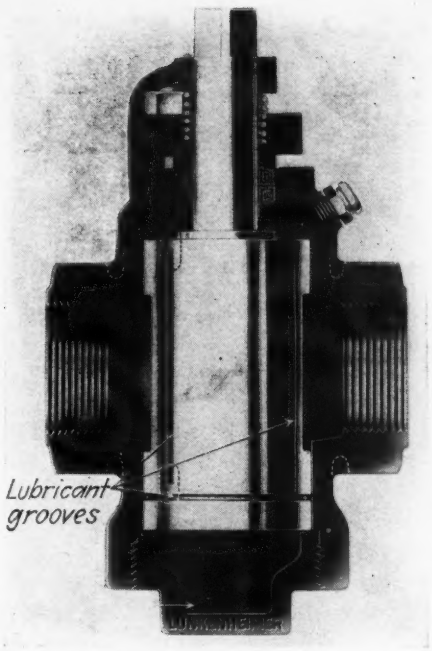
Vivian solid-injection diesel

unit was designed primarily for marine purposes it is equally applicable to general power installations.

The frame consists of a crankpan and an upper base upon which the several cylinders are bolted. The camshaft is inside the housing, and pushrods, shown along the cylinders, actuate the valve rockers concealed in aluminum covers on the cylinder heads. The Bosch fuel pump and injection nozzles are employed. A fuel consumption of 0.42 lb. per horsepower-hour is claimed.

Lubricated Rotor Valve

IN THE Slaset valve illustrated lubricant is forced into the reservoir above the closed top of the rotor, the pressure forcing the rotor down as the reservoir fills. The pipe line pressure, aided by an external spring, causes the rotor to act as a booster plunger, which forces the lubricant into pockets in the body and grooves in the rotor, from which it is distributed to form a protecting lubricant film for the bearing surfaces,



Slaset valve has flexible stem and rotor connection

as well as a seal when the valve is closed.

An important feature of the valve is that the stem and rotor are not integral, the stem being made of steel. The flexible stem-rotor connection permits the rotor to seat without binding or "cocking," even though the packing may be compressed unevenly around the stem. It is also an aid to tight closure, as pressure in the line holds the rotor against the outlet port, without any interference from the steam.

The Slaset valve, which is manufactured by the Lunkenheimer Company, Cincinnati, Ohio, is made with screw ends for 150 lb. and flange ends for 125 lb. gas or liquid pressure at 150 deg. F. and is suitable for use in various industries.

Push Button-Operated Starter

THIS three-pole starter is designed to control across-the-line single and polyphase motors, and is suitable for general applications where remote control and low-voltage protection are not essential.

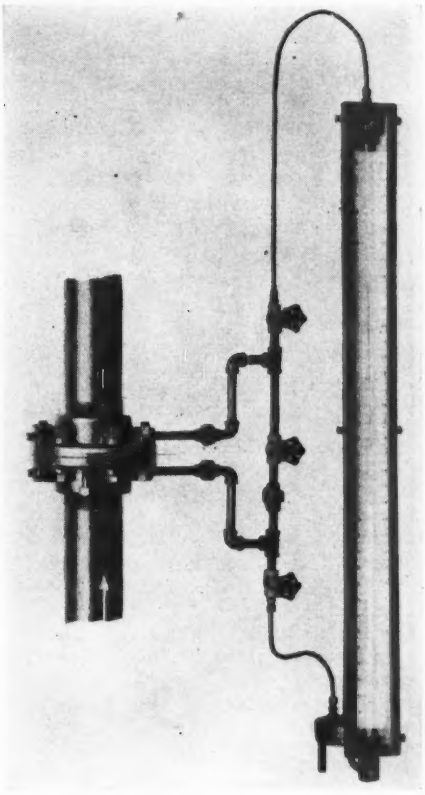
Class 2510-W5 manual starter

Overload protection is provided by time-limit thermal relays which are front reset and require no replacement of parts after operation. Tripping of either relay opens all three lines. The starter is arranged for wall or pedestal mounting. It is put out by the Square D Company, 710 South Third St., Milwaukee, Wis.

High-Range Manometer

A HIGH-RANGE MANOMETER, Model 391, for checking the accuracy of recording flow meters has been announced by the Meriam Company, Cleveland, Ohio. This instrument has a steel frame, stainless-steel glands, plate-glass cover, and is tested to 1,000 lb. hydraulic pressure.

Mercury, water or Meriam No. 3 Fluid, having a specific gravity of 2.97,



Meriam Model 391 manometer

may be used. With the No. 3 Fluid the manometer will read 100 in. of water. The standard scale is 35 in. long, the right side is graduated in inches and tenths, and the left side 0 to 100 in. and tenths of water using Meriam No. 3 Fluid.

This instrument can be used as an indicating flow meter. When used for this service an orifice plate, orifice flanges, special scales reading directly in gallons, cubic feet, pounds or any commercial units of measurement, liquid return well, control and bypass valves are available from the manufacturer.

The standard instrument is 42 in. high, 6 in. deep, 4½ in. wide and weighs approximately 20 pounds.

NEWS of the FIELD

A.E.C. Reports Widespread Progress in Relieving Unemployment Among Engineers

UNEMPLOYMENT is being cut down, public works projects aggregating many millions speeded, and plans to stabilize work in industry are going into effect in many parts of the country as a result of the efforts of 52 committees of the American Engineering Council, according to a progress report made public by the president of the council, William S. Lee. Encouraging business conditions are reported in some sections.

The engineers have established cooperation with industries, states and municipalities, chambers of commerce and other trade bodies, federal agencies, including the President's Organization for Unemployment Relief, and civic and service organizations. Coordination of relief activity has been accomplished in scores of cities and towns, spread work programs have been fostered in factories, highway improvement has been stimulated, and budget studies to encourage sound municipal and state financing have been made.

Thousands of industrial plants have been surveyed, and new policies to expand business, to effect operating economies, and to prevent the further discharge of workers have been shaped. Changes in industrial management affecting sales, balancing of demand for diversified products, development of new lines of products, simplification of products, plant rehabilitation, reduction of overtime, adoption of alternating shifts, and temporary curtailment of the number of working days in a week are among the reforms actively sponsored by the engineers.

Everywhere the engineers are opposing the dole as a "pauperizing" influence. Charity is being eliminated as far as possible, direct financial relief being largely afforded in the form of loans. Charity organization funds are being diverted to community betterment work and other measures of self-help which create jobs.

Surveys have disclosed that in most of the sparsely settled states unemployment among engineers is comparatively small, amounting to about 4 or 5 per cent, while in the highly industrialized states the percentage is 20 to 48.

The engineering committees are also active in behalf of federal legislation, which, the report says, "will be of great significance to the employment of engineers in years to come."

They favor the passage of the bill introduced in the House by Representative Green of Florida and sponsored by the American Institute of Architects requiring the supervising architect of the Treasury to employ engineers and architects in private practice to design and construct public buildings, thereby eliminating "bureaucracy" in federal architecture.

The engineers are also urging the passage of the bill of Representative Cochran of Missouri to establish an Administration of Public Works, as advocated by President Hoover, who was the first president of the council. "This is a much needed piece of government reorganization," the council report declares.

A marked social advance, the Council predicts, will result from the present widespread relief activity. Better relations between employers and employes are being built up, a sober view of public financing is being taken, and corporate management is being shaped along sounder lines. These and other constructive developments arising from the depression will, it is asserted, make for a more stable economic organization.

N. J. Bill Enables Counties To Set Up Smoke Departments

A BILL granting to counties in New Jersey the power to establish departments of smoke regulation has just been introduced in the State Legislature. If passed, the act will greatly further the work of smoke abatement throughout the state.

The bill provides that each smoke regulation department set up by a county shall consist of an advisory board, smoke abatement engineer and such deputy engineers and inspectors as are necessary. Each advisory board shall have on it not less than three nor more than five competent professional engineers, who will serve without pay. The smoke abatement engineer and deputies shall have such qualifications as are required for active membership in the A.S.M.E., while the inspectors must have had at least ten years' experience as locomotive, marine or stationary engineers or firemen.

Duties of the department of smoke regulation shall be to regulate the installation and operation of all fuel-burning equipment "to the end that no deleterious or obnoxious substance or gas shall be discharged into the air." To this end the department shall formulate rules governing equipment and its operation, and shall have the power to prosecute all violations of the approved regulations. The bill provides a maximum penalty for any violation of 90 days in jail or a fine of $200, or both.

Oregon Grange Urges State Power Systems

STATE-OWNED power systems is the object of a constitutional amendment proposed by the Oregon Grange and filed recently with the secretary of state.

The amendment would authorize the State of Oregon to develop water power within the state; to transmit, distribute and sell electric energy; to develop water power in conjunction with the United States or in conjunction with other states or political subdivisions thereof; to contract with the United States or other states for the purchase of water power and electric energy; to fix rates for the use of water power and electric energy; and to incur indebtedness to an amount not exceeding 6 per cent of the assessed valuation of all the property in the state to provide funds for these purposes.

As soon as the attorney general provides a ballot title for this measure, the Grange proposes to circulate petitions to place the measure on the ballot by initiative at the next general election in November.

A.S.A. to Standardize Measurement of Noise

ORGANIZATION of a sectional committee on noise measurement under the procedure of the American Standards Association was recommended by a general conference of 32 representatives of 18 national bodies, held recently in New York. It was also recommended that the committee function under the technical leadership of the Acoustical Society of America.

The scope of the project as recommended by a steering committee consisting of Prof. Vern O. Knudsen and Dr. Harvey Fletcher, Acoustical Society of America; E. E. Free, American Society of Mechanical Engineers; P. L. Alger, American Institute of Electrical

Engineers; H. R. Summerhayes, National Electrical Manufacturers Association; and R. G. McCurdy, A.S.A. Telephone Group, is as follows:

"Preparation of general standards of nomenclature, units, scales, and measurement in the field of acoustics, with special reference to noise measurements."

The conference followed a request made by the Acoustical Society to the A.S.A. to set up a national committee to correlate the activities of various technical and trade organizations which have been attempting individually to set up standards for noise measurement. Eight such organizations now have committees on this subject. It was pointed out that the diverse nomenclature and methods of measurement growing out of these uncorrelated activities were interfering with the progress of scientific work on the subject and that without real national standardization this condition would become worse as different individuals became accustomed to different concepts and terms.

W. D. Coolidge to Receive Washington Award, Feb. 24

THE WESTERN SOCIETY OF ENGINEERS together with the four Founder Societies will present, on Feb. 24, the Washington Award for 1932 to Dr. William D. Coolidge, associate director of the research laboratory of the General Electric Company.

This yearly award is given in recognition of pre-eminent service on the part of some engineer in advancing human progress. The world owes much to Dr. Coolidge for his development of ductile, metallic tungsten used as filament in incandescent lamps, vacuum tubes and other lamp types, as well as for his work on the X-ray tube and other thermionic devices in this field.

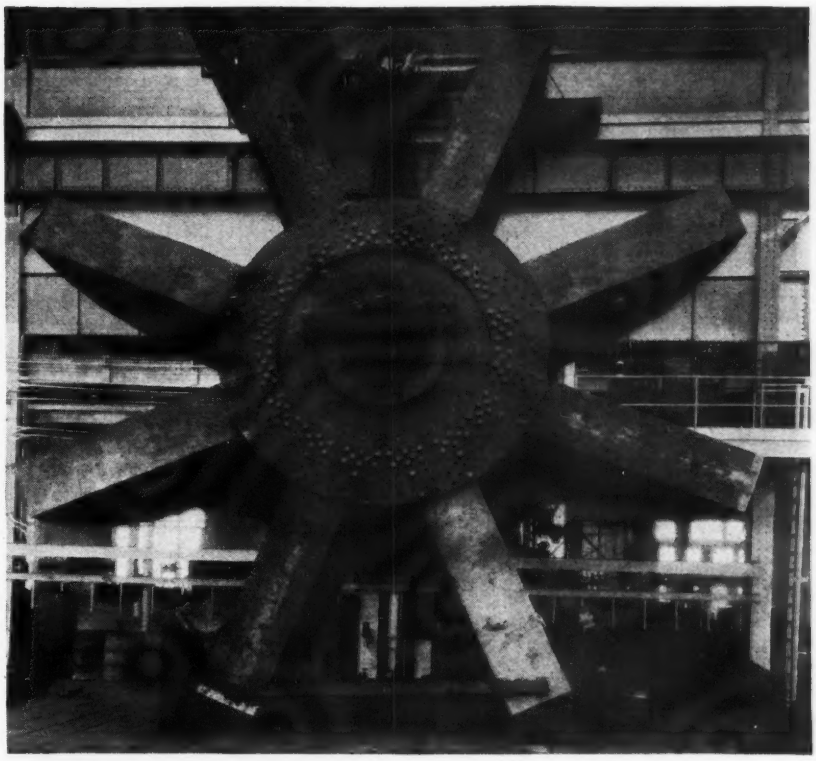
Ohio Electric to Purchase 13 Companies at $20,000,000

PLANS TO EXPAND the activities of the Ohio Electric Power Company, an operating subsidiary of the National Electric Power Company, through the acquisition of thirteen power firms at a cost of approximately $20,000,000, were revealed in a petition filed Feb. 6 with the Ohio Public Service Commission. The petition was a joint application on the part of Ohio Electric Power to purchase and of the thirteen other companies to sell; it also sought issuance of securities to finance the consolidation.

The thirteen companies involved in the transaction are the Columbus, Delaware & Marion Electric Company; Mt. Gilead Water, Light & Heat Company; Morrow Public Service Company; New London Power Company; General Utilities Company; Ohio Northern Public Service Company; City Water Company; Buckeye Public Service Company; Asheville Light & Power Company; West Jefferson Power & Light Company; Central Utilities Service Company; Reserve Power & Light Company; and Western Reserve Power & Light Company.

On completion of the consolidation, the holdings of the Ohio Electric Power Company will form a centralized system operating in over half the counties of the state and serving a population of more than 200,000. Gross revenues of the company will be increased to about $5,000,000 yearly and total assets to $27,000,000.

HUGE "SPIDER" FOR DNEIPER UNIT



A 90-ton bearing bracket for one of the ten 77,500-kva. water-wheel generators which the General Electric Company is building for the 800,000-hp. hydro-electric plant on the Dneiper River in Soviet Russia. An electric crane is just about to turn the "spider" on its back

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Eagle Pass Project Nears Completion

THE Central Power & Light Company's 13,500-hp. hydro-electric project near Eagle Pass, Texas, which is part of a new development to irrigate thousands of acres of hitherto barren area in southern Texas, will be completed on or about March 1, according to a recent announcement.

The first section of the 90-mile canal which will divert water from the Rio Grande at a point above the dam is virtually completed. The power plant installation includes three 4,500-hp. francis-type water wheels, operating at 225 r.p.m. on a static head of 81 feet.

Municipal Power Show at Rochester, Minn., Feb. 24-26

A POWER SHOW and competitive fuel test will be held at Rochester, Minn., on Feb. 24 to 26, by the City Light Plant of Rochester and the Minnesota League of Municipal Electrical Utilities. Features of the program include a 24-hr. test on identical boilers burning different fuels, lectures and moving pictures on power subjects, social events and an exhibition of power equipment.

Starting at 10 a.m. on Feb. 24, the test will be made in the Rochester municipal plant on boilers of practically the same heating surfaces, furnace volumes and air preheat, operating under actual daily load conditions. Coal and natural gas will be used for fuels, and if time permits, short runs will be made using fuel oil. It is expected that interesting results will be obtained from this test.

The lectures will cover valves and pressure-control equipment, selection of fuel and combustion, natural gas and oil burners, meters, stoker design and operation, boilers and furnaces, and feed-water treatment. In addition, industrial leaders and economists will discuss various phases of municipal ownership and operation.

A number of manufacturing companies will have on display and in actual operation many different types of power plant apparatus.

Capacity of Hydro Plants Increases 681,000 Hp. in 1931

TOTAL CAPACITY of water wheels at water-power plants in the United States on Jan. 1, 1932, according to the annual report just released by the Department of the Interior through the Geological Survey, was 15,562,805 hp., an increase during the year of 681,000 hp., or 4.3 per cent.

Capacity of water-power plants in the latter part of 1921 was 7,927,000 hp. In the ten years since 1921 the capacity has practically doubled, and the increase has averaged about 760,000 hp. a year. This average growth is noteworthy, the report states, because during this same period the development and improvement of steam power-plant equipment and the increase in the efficiency of operation of steam plants have been almost phenomenal.

The capacity of water-power plants as given in this report shows that there was an increase of 25,000 hp. or more during 1931 in each of the states of Maine, Pennsylvania, Georgia, Missouri, Arkansas, Washington and California.

The complete report shows the total capacity of water wheels in plants of 100 hp. or more by states and main divisions of the United States, segregated between public-utility companies and manufacturing companies. It gives the trend in development in different sections of the country and the rank of the ten leading states in developed water power from 1921 to 1932. Copies of the complete report may be obtained upon application to the Director, United States Geological Survey, Washington, D. C.

Record Installation of Mercury-Arc Rectifiers

THE LARGEST INSTALLATION of mercury-arc rectifiers in this country, and probably in the world, is being made beneath the streets of New York City to supply direct-current power for the operation of the new Eighth Avenue subway in the boroughs of Manhattan, Queens, Bronx and Brooklyn. The initial unit of this new subway is expected to be started in operation in the near future, and the portion of the project now contracted for and under construction will include more than 200 track-miles in the four boroughs.

For supplying third-rail power in this new subway system a total of 51 mercury-arc rectifiers, totaling 153,000 kw. are either under construction or already installed, nad 53,000 kw. of synchronous converters are ready for operation in five surface substations. All are of General Electric manufacture.

The location of the rectifiers below street level is unique. Underground rooms, constructed of reinforced concrete adjacent to the subway, are located at different depths according to the particular conditions involved. All of the switching equipment is automatic, with remote supervisory control, and the distribution of the various units along the right-of-way is such as to minimize as far as possible the necessity for expensive feeder equipment.

COMING CONVENTIONS

American Society of Mechanical Engineers. Spring meeting at Bigwin Inn, Lake of Bays, Ont., Canada, June 27-July 1. Oil and Gas Power meeting at Pennsylvania State College, June 8-11. Secretary, Calvin W. Rice, 33 West 39th St., New York City.

American Institute of Electrical Engineers. District meetings at Milwaukee, Wis., March 14-16, and Providence, R. I., May 4-7. Annual summer convention at Cleveland, Ohio, June 20-24. Secretary, F. L. Hutchinson, 33 West 39th St., New York.

American Boiler Manufacturers Association. Annual convention at the Greenbrier Hotel, White Sulphur Springs, W. Va., May 23-25. Secretary, A. C. Baker, 801 Rockfeller Building, Cleveland, Ohio.

American Society for Testing Materials. Committees group meetings in Cleveland, Ohio, March 7-11. Annual meeting at Chalfonte-Haddon Hall, Atlantic City, N. J., June 20-24. Secretary, C. L. Warwick, 1315 Spruce St., Philadelphia, Pa.

American Water Works Association. Annual convention at the Hotel Peabody, Memphis, Tenn., May 2-6. Secretary, Beekman C. Little, 29 West 39th St., New York City.

American Welding Society. Annual meeting in New York City, Apr. 27-29. Secretary, M. M. Kelly, 33 West 39th St., New York City.

Association of Iron and Steel Electrical Engineers. Annual convention in Pittsburgh, Pa., June 20-24. Managing Director, John F. Kelly, Empire Building, Pittsburgh.

National District Heating Association. Annual convention at the William Penn Hotel, Pittsburgh, Pa., June 14-17. Secretary, D. L. Gaskill, Greenville, Ohio.

National Electric Light Association. Annual convention in the Atlantic City Auditorium and Convention Hall, Atlantic City, N. J., June 6-10. Secretary, A. Jackson Marshall, 420 Lexington Ave., New York City.

SECTION MEETINGS

A.S.M.E., Bridgeport Section. Meeting at the University Club, Feb. 25 at 8 p.m. Subject: "Vibration of Internal-Combustion Engines," J. Ormontroyd.

A.S.M.E., Metropolitan Section. Meeting at the Engineering Societies Building, Feb. 18 at 8 p.m. Subject: "Research on Cyclone Dust Collectors," L. C. Whiton, Jr. Dinner meeting at Cavanagh's Restaurant, Feb. 25 at 6:30 p.m. Subject: "The Automatic Diesel Plant for City Buildings," C. F. Strong.

A.S.T.M., New York Section. Joint meeting with A.I.M.E. at the engineering Societies Building, Feb. 18 at 8 p.m. Subjects: "Limits of Our Knowledge of the Properties of Metals," F. O. Clements; "Test Results and Service Values of Metals," H. F. Moore; and demonstration of welding tests.

N.A.P.R.E. First Pacific Coast conference at the Civic Auditorium, San Francisco, Calif., Feb. 17-18. Washington, Oregon, California and Arizona chapters will take part.

Prof. H. B. Smith, Noted Electrical Engineer, Dies

HAROLD BABBITT SMITH, retired head of the department of electrical engineering at Worcester Polytechnic Institute and past-president of the American Institute of Electrical Engineers, died Feb. 9 at his home in Worcester, Mass. Professor Smith, who had been ill for several years, was 61 years old.

Born in Barre, Mass., Professor Smith was educated at Cornell University, where he received the degree of mechanical engineer in 1891. After post-graduate study at Cornell, he became professor of electrical engineering at the University of Arkansas in 1892, and the next year went to Springfield, Mass., as head designer of the Elektron Manufacturing Company.

After a few months at Springfield he was appointed professor of electrical engineering at Purdue University, where he remained until 1896 as director of the school of electrical engineering. In 1896 he joined the faculty of Worcester Polytechnic Institute as professor of electrical engineering and head of the department, retiring in 1930.

Professor Smith was electrical engineer, consulting engineer and designer of the Westinghouse Electric & Manufacturing Company at Pittsburgh since 1905. He was a member of the American Society of Mechanical Engineers, the Society for the Promotion of Engineering Education, the Institution of Electrical Engineers of Great Britain, and the American Association for the Advancement of Science.

Simplification Campaign Started by Penn. Chamber

THE Pennsylvania State Chamber of Commerce is preparing for a state-wide simplification program and is engaged in the appointment of working committees. The advisory committee which is now at work on this program consists of the following members. F. W. Walker, Beaver Falls, chairman; William Mann, Wm. Mann Company, Philadelphia; C. B. Auel, Westinghouse Electric & Manufacturing Company, East Pittsburgh; J. A. Longacre, American Equipment Company, Norristown; E. J. Poole, Carpenter Steel Company, Reading; and R. K. Laros, R. K. Laros Silk Company, Bethlehem.

Like the activity of the California State Chamber of Commerce, which has been similarly engaged for more than two years, the purposes of the program will be two-fold: to disseminate information regarding what has already been done by manufacturers, distributors, and users to eliminate waste through the process of simplification, by directing attention to the currently active simplified practice recommendations; and to extend the application of simplification to commodities produced and used by Pennsylvanians.

Personals

W. C. SHARP, vice-president of the Middle West Utilities Company in charge of operations since 1924, has retired after more than 30 years of service in the public utility industry. Starting with the New York Edison Company in 1900, he became identified with the meter department and later had charge of coal and boiler testing. Subsequent connections followed with the Des Moines Electric Light Company, the J. G. White interests, and A. E. Fitkin & Company, until in 1921 he joined the Middle West company.

L. M. KLAUBER, vice-president and general superintendent of the San Diego Consoldiated Gas & Electric Company, has been elected vice-president in charge of operation.

WILLIS H. CARRIER, president of the American Society of Heating and Ventilating Engineers, received the first award of the F. Paul Anderson gold medal, "for distinguished scientific achievements in the field of heating, ventilating and air conditioning," at the society's annual meeting held recently in Cleveland.

C. O. STREETER, well-known mechanical engineer in the power-transmission field, has severed his connections in New York City and returned to his home in Shrewsbury, Mass., His plans for the immediate future are not definitely settled.

DANIEL F. RITCHIE, formerly equipment sales engineer for the Allis-Chalmers Manufacturing Company, at Springfield, Ill., has become designing engineer with the LaPlant Choate Manufacturing Company, Cedar Rapids, Ia.

KERN DODGE, consulting mechanical engineer, has been appointed director of the Department of Public Safety of Philadelphia by Mayor J. HAMPTON MOORE. Mr. Dodge has charge of the police and fire bureaus, numbering more than 7,000 men.

WALTER J. ARMSTRONG, consulting engineer, announces the opening of his office at 1135 Beaver Hall Hill, Montreal, Que., offering a complete consulting and supervising service in mechanical and electrical work.

HOWARD E. AMES, for twelve years engineer with Fairbanks, Morse & Company, Chicago, has joined the Marathon Oil Company, Tulsa, Okla., refining and marketing division of the Ohio Oil Company, as engineer in the lubricating oil department, specializing on diesel engines.

E. S. FITZ, who has been manager of production and transmission for the Virginia Electric & Power Company, was recently promoted to the position of general manager of the electric department for the entire system.

How's Business?

SIGNS of seasonal pick-up, almost invariably marked by the middle of this month, are so far very slight and scattered. Carloadings and electric power production (1,588,853,000 kw.-hr. for the week ended Feb. 6, according to the N.E.L.A.) are moving almost horizontally. Despite some revival of railroad buying, the spring rise in steel is being held back by slackness in automotive output due to delays in Ford's new models for which buyers and other producers are disposed to wait. Commodity and stock price averages have sagged to new lows and bonds lost a large part of their gain since December—*The Business Week*, Feb. 17.

Business Notes

I. P. MORRIS & DE LA VERGNE DIVISION of the Baldwin-Southwark Corporation, Philadelphia, Pa., recently appointed James H. Galloway head of the diesel engine department. Mr. Galloway has been manager of the Kansas City office.

ALLEN-BRADLEY COMPANY, Milwaukee, Wis., is now holding an extensive exhibit of motor-control equipment at the Engineering Building, 205 West Wacker Drive, Chicago, Ill. Eugene F. LeNoir, assisted by several members of the company's engineering staff, is in charge of the display, which shows the entire Allen-Bradley line.

MUNDET CORK CORPORATION, New York City, announces the appointment as sales representative of the Pioneer Sand & Gravel Company, Insulation Division, 911 Harrison St., Seattle, Wash.

BAILEY METER COMPANY, Cleveland, Ohio, has appointed W. J. Reeder, of its Chicago office, manager of the St. Louis branch office, located at 127 Waterman Building, 457 North Kingshighway. This appointment fills the vacancy caused by the untimely death of C. J. Prendergast, which resulted from injuries received in a building collapse at Paoli, Ind., a short time ago.

GENERAL ELECTRIC COMPANY, Schenectady, N. Y., reports that orders received during 1931 totaled $252,021,496, compared with $341,820,312 for 1930, a decrease of 26 per cent. Orders for the quarter ended Dec. 31 amounted to $49,321,480, compared with $74,168,480 for the last quarter of 1930, a decrease of 34 per cent.

THE DAMPNEY COMPANY OF AMERICA, Hyde Park, Boston, Mass., announces that Clarence J. Hunter, formerly Philadelphia district manager and then general sales manager, has been elected vice-president in charge of sales.

INDUSTRIAL BROWNHOIST CORPORATION announces the removal on Jan. 15 of its general offices from Cleveland, Ohio, to Bay City, Mich. This move, by consolidating the executive offices, sales, engineering and purchasing departments at the principal manufacturing plant, will effect increased efficiency and convenience in operation, the company states. A district sales office will be continued at 4403 St. Clair Ave., Cleveland.

Trade Catalogs

REFRACTORIES—An exceptionally complete refractory catalog (No. 145-H) has just been issued by the Denver Fire Clay Company, P. O. Box 1107, Denver, Colo. Besides describing and illustrating the company's line of standard refractory products, this publication gives useful information on fire-brick construction features and installations.

CENTRIFUGAL PUMPS — Bulletin 1642B, recently published by the Allis-Chalmers Manufacturing Company, Milwaukee, Wis., describes Type "M" double-suction, multi-stage, centrifugal pumps. It contains tables of dimensions and many illustrations showing construction features and typical installations of these units.

OIL BURNERS—Various types of fuel-oil burners, designed to operate with live steam, blower air or pressure air, are covered in Bulletin No. 16-G just issued by the Schutte & Koerting Company, 12th and Thompson Sts., Philadelphia, Pa. Illustrations in color, supplemented by brief text, effectively depict the design and operation of the burners.

SUCTION-LINE PRIMER — An illustrated description of the construction, operation and applications of the new Hazleton suction-line primer is contained in Bulletin 530, just issued by Barrett, Haentjens & Company, Hazleton, Pa.

MOTORS—Two new bulletins on a.c. motors have just been issued by the Wagner Electric Corporation, 6400 Plymouth Ave., St. Louis, Mo. Construction features of polyphase squirrel-cage motors are covered on Bulletin 167—Part 7, while Bulletin 173—Part 4 gives similar data for Type RG brush-riding repulsion-induction motors.

HEATING SYSTEMS—An attractive catalog on heating specialties has just been issued by Sarco Company, Inc., 183 Madison Ave., New York, N. Y. It describes and illustrates typical vacuum and vapor heating systems, together with a full line of thermostatic specialties including radiator traps, packless valves, receivers, air eliminators, etc.

NEW PLANT CONSTRUCTION

COMPILED BY THE McGRAW-HILL BUSINESS NEWS DEPARTMENT, WHICH IS PREPARED TO FURNISH A MORE COMPLETE DAILY SERVICE TO THOSE WHO WISH IT

California — Southern California Edison Co. Ltd., 601 West 5th St., Los Angeles, program for 1932 involves expenditure of approximately $11,397,000 including the following: Alhambra district 6325 hp. to be added to service, $240,000. Compton district, 5200 hp. $380,000. Covina district, 3050 hp. $175,000. Fullerton district, 4150 hp. $165,000. Huntington Beach district, 3800 hp $245,000. Inglewood district, 4850 hp. $180,000. Lancaster district, 2400 hp. $165,000. Long Beach district, 29,850 hp. $500,000. Monrovia district, 2200 hp. $105,000. Montebello district, 5450 hp. $175,000. Ontario district, 3825 hp. $195,000. Oxnard district, 3900 hp. $245,000. Pasadena district, 4300 hp. $190,000. Pomona district, 8050 hp. $220,000. Porterville district, 4525 hp. $130,000. Redlands district, 4150 hp. $220,000. Redondo Beach district, 5450 hp. $250,000. San Bernardino district, 4850 hp. $275,000. San Fernando Valley district, 2300 hp. $190,000. Santa Ana district, 7325 hp. $220,000. Santa Barbara district, 7550 hp. $235,000. Santa Monica district, 19,150 hp. $550,000. Santa Paula district, 2225 hp. $110,000. Tulare district, 3350 hp. $250,000. Ventura district, 3250 hp. $95,000. Vernon district, 16,650 hp. $340,000. Visalia district, 5650 hp. $280,000. Whittier district, 6225 hp., $310,000.

Calif., Stockton—State Department of Public Works, Sacramento, will receive bids until March 1 for construction of refrigeration plant and kitchen addition at State Hospital here. Estimated cost $118,000.

Calif., Sunnyvale—Bureau of Yards & Docks, Navy Department, Washington, D. C., will receive bids until March 2 for two gravel wall wells, pumps, pump houses, etc., at Naval Air Station here.

Fla., Pensacola—Bureau of Yards & Docks, Navy Department, completing plans and specifications for construction of sewage system including reservoir and pump house, motor driven sewage and sump pumps, with control equipment, etc., at Naval Air Station here. Estimated cost $75,000.

Idaho, Coeur d'Alene—City voted $600,000 bonds for construction of municipal hydro electric plant.

Ill., Chicago—Board of Local Improvements, B. F. Lindheimer, Pres., City Hall, will receive bids about March 10 for construction of bridge operators' houses at Ogden Ave. and Chicago River. W. L. Mulcahy, 139 North Clark St., is engineer. Electrical equipment awarded to Pierce Electric Co., 367 West Adams St. $148,227. Estimated total cost $200,000.

Ill., Chicago—A. W. Swayne Building Corp., 520 North Michigan Ave., awarded contract for construction of a 22 story co-operative apartment building at Sheriden Road between Belmont and Melrose Sts. to A. W. S. Construction Co., 520 North Michigan Ave. Estimated cost $1,400,000. Steam heating, ventilation and refrigeration systems, boliers, pumps, etc., will be installed.

Ia., Dubuque—City having plans prepared for construction of a coal terminal, 400 x 1,200 ft. including portable conveyors, scale, sea wall, dredging, etc. Estimated cost $150,000. F. B. Schmidt, c/o owner, is engineer. Mississippi Coal Co. is lessee.

Ia., Marion—Clark & Jacoby, Kansas City, Mo., Consulting Engineers, conducting survey to determine size and location of new gas plant to be constructed here for City of Marion.

Ia., Sumner—City having preliminary surveys made for construction of a municipal light and power plant. H. L. Cory, 3905 North 17th St., Omaha, Neb., is engineer.

Kan., Oswego—City is having plans and specifications made for construction of municipal gas plant and distribution system. Estimated cost $32,000. Emporia Engineering Co., Emporia, is engineer.

Mich., Windmill Pointe (Grosse Pointe)—U. S. Government, Marine Hospital, Detroit, having plans prepared for construction of 3 or 4 story hospital, nurses' home, etc., including steam heating and ventilation systems, boilers, elevators, etc., at Alter and Riverside Roads. Estimated cost $600,000. Eston & Ellington, 1507 Stroh Bldg., Detroit, are architects and engineers.

Mo., Deepwater—City plans election in spring to vote $39,000 bonds for waterworks including pumping equipment, distribution system, etc. W. B. Rollins & Co., 339 Railway Exchange Bldg., Kansas City, are engineers.

N. J., Franklin—Alfred Littell, plans construction of an artificial ice plant. Estimated cost $400,000. Architect not selected.

N. J., Newton — M. K. Pickett & Son, 21 Townsend St., plans construction of a 1 story artificial ice manufacturing plant. Estimated cost $40,000. Architect not announced.

N. Y., Jackson Heights (sta. Flushing) — Pennsylvania R.R., Broad St. Station, Philadelphia, Pa., plans construction of a 1 story, 27 x 27 ft. railroad sub-station at Austin Pl. and Herrick Ave. here. T. J. Skillman, Philadelphia, is chief engineer.

N. Y., North Creek—Water Commissioners of North Creek Water District, I. V. Toole, Chn., will receive bids until February 24 for construction of waterworks system including earth dam, 280 ft. long and 30 ft. high, storage reservoir, 100,000 gal. storage tank, distribution system, chlorinator and house for same together with automatic pressure control and relief valves for supply main. Solomon & Keis, 257 Broadway, Troy, are consulting engineers.

N. D., Grand Forks—Red River Valley Power Co., subsidiary of Northern States Power Co., receiving bids for construction of 22 x 50 ft. machine shop and filter house, 1 story, 14 x 66 ft. switch gallery and cable vault at power plant. D. Keeley, in charge of construction.

O., Orrville—Board of Public Affairs, awarded contract for a new 1,500 kw., 1,875 kva. turbo generator and surface condensing equipment in connection with municipal light plant. Foundations and other equipment will be installed by city forces.

Okla., Oklahoma City—Quix Kold Corp., Norman, having preliminary plans prepared for construction of a dry ice plant here. Estimated cost $40,000. H. A. Wright, Norman, is engineer.

Pa., Erie—St. Vincents Hospital, plans campaign to raise funds for addition to hospital, nurses' home and power plant. Estimated cost $400,000. Architect not selected.

Pa., Philadelphia—J. J. Greenberg, Fidelity and Philadelphia Bldg., awarded contract for construction of an 8 story store, and office building and broadcasting station at 1618-20-22 Chestnut St. to Wark Co., 1608 Walnut St. Estimated cost $500,000. F. W. Woolworth Co., lessee.

Pa., Pittsburgh—U. S. Engineers Office, War Dept., Washington, D. C., will receive bids until February 24 for construction of a power house and administration building at Lock No. 4 on Monongahela River.

Pa., Wilkes-Barre—Swift & Co., 60 North Market St., Boston, Mass., will soon award contract for construction of a 2 story, 85 x 130 ft. warehouse including boiler and cooler, etc., on Pennsylvania Ave. here. Estimated cost $100,000.

Va., Langley Field—Constructing Quartermaster will receive bids until February 29 for construction of transformer vaults, transformer house and underground electric distribution system.

Wash., Kittitas—City plans an election February 15 for improvements to waterworks system including 100,000 gal. storage reservoir, drilling 12 in. well, purchase and installation of 250 g.p.m. or less motor driven well turbine pump, and one 250 g.p.m. motor driven centrifugal booster pump. J. R. Bannon is city engineer.

Wash., Tacoma—City will soon start work on construction of Hood Street pumping station, appurtenant structures and connecting pipe lines. Estimated cost $116,136. W. A. Kunigh, c/o Water Dept., is engineer. Work will be done by day labor.

Ont., Kincardine—Kincardine Pure Ice Co., W. and F. Morgan, having plans prepared for construction of a 1 story, 40 x 100 ft. ice manufacturing plant to be equipped with electrically operated equipment.

Ont., Windsor—Windsor Elevator & Warehouse Co., c/o W. A. MacKenzie Ltd., 67 Yonge St., Toronto, having plans prepared for construction of a 208 x 480 ft. grain elevator 2,000,000 bu. capacity including 65 x 299 ft. cold storage warehouse and 40 x 480 ft. wharf here. Estimated cost $750,000. Wynne-Roberts Son & McLean, Metropolitan Bldg., Toronto, are engineers.

Sask., Veregin—Christian Community, c/o Peter Veregin, plans construction of a jam factory, flour mill and power plant. Estimated total cost $120,000. Interested in prices on equipment.

Equipment Wanted

Boiler—Washington, D. C.—Treasury Department, Office of J. A. Wetmore, Supervising Architect, will receive bids until March 7 for installation of a boiler in central heating plant for Public buildings and grounds.

Engines, Generators, Etc.—Grand Junction, Ia.—City Council will receive bids until March 8 for two 265 hp. or two 240 hp. Diesel engines; two 185 or two 170 kw. electric generators direct connected to above mentioned engines in connection with proposed 37 x 47 ft. municipal power plant. Estimated cost $85,000.

Power Equipment—New York, N. Y.—Board of Transportation, J. H. Delaney, Chn., will receive bids until March 2 for furnishing and installing power equipment for Fulton Street Line of Independent System of City-Owned Rapid Transit Railroads.

Industrial Projects

Calif., Los Angeles—Willard Storage Battery Co., 5700 East 9th St., awarded contract for addition storage battery plant, including erection of lead oxide mill, acid-reclaiming plant and enlargement of administration building to William P. Neil Co., 4814 Vista St. Estimated cost $100,000.

Ind., South Bend—Furness Ice Cream Co., awarded contract for construction of a 2 story, 90 x 145 ft. ice cream plant at 825 South Main St. to Equity Construction Co., 25 West 43rd St., New York. Estimated cost $150,000.

N. J., Woodbridge — Benjamin Farer, 59 Avonal St., will receive bids about March 15 for a 2 story addition to factory. Estimated cost $40,000. E. C. Wierzlicki, 175 Smith St., Perth Amboy, is architect.

Pa., Ambridge—H. H. Robertson Co., Grand Bldg., Pittsburgh, have asked Ambridge Council to vacate three streets to enable them to build steel floor plant here. Private plans.

Tex., Houston—Pan American Petroleum & Transport Co., 122 East 42nd St., New York, N. Y., having plans prepared for construction of a new oil refinery including power house, pumping plant, storage building, distribution, mains, etc., in vicinity of Houston. Estimated cost to exceed $1,000,000. **Maturity indefinite.**

Utah, Siguard — Jumbo Plaster & Cement Co., plans to rebuild gypsum plant destroyed by fire. Estimated cost $250,000.

Ont., Amherstburg—Simrall Refining Corp. of Canada, 814 Union Central Bldg., Cincinnati, O., awarded contract for construction of a refinery for gasoline and fuel oils here to Foster-Wheeler Ltd., Canadian Pacific R.R. Bldg., Toronto. Estimated cost $200,000.

Ont., Port Colborne — Highland Scotch Distillers, J. B. Disher, Mgr., plans addition and improvements to plant, including additional story to existing plant, new boiler house, rack warehouse and installation of new equipment.